STUDY AND ANALYSIS ON ALTERNATIVES TO MANUAL PATCHING

TASK 79-3

Prepared for

U. S. AIR FORCE COMMUNICATIONS COMMAND
Scott AFB, Illinois

Under

Contract F23613-77-D-0011

Delivery Order 009

CSC

COMPUTER SCIENCES CORPORATION

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Major Offices and Facilities Throughout the World

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This report analyzed and investigated methods for providing alternatives to manual patching in Technical Control Facilities (TCF) and Patch and Test Facilities (PTF). It addresses the application of commercially available switching systems in meeting automated patching requirements.

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EXECUTIVE SUMMARY

ES.1 PURPOSE

The purpose of this report was to study, analyze, and investigate methods for alternatives to Manual Patching in Technical Control Facilities (TCF) and Patch and Test Facilities (PTF). This study analyzes and addressed the application of commercially available switching systems in meeting this automated patching requirement.

This report presents the results of this study and analysis effort.

ES.2 BACKGROUND

The Technical Control Facility is the focal point of communications systems. The Technical Control Facility is equipped with patching facilities upon which all circuits appear to allow the Technical Controller to perform the functions of circuit control, testing and restoral.

Present day Technical Control Facilities and Patch and Test Facilities have grown in size and complexity due to integration of new and more sophististicated transmission and switched systems. This in addition to the expansion and upgrade of present systems, has seriously impacted the manpower intensive manual patching functions at these facilities.

The Technical Controller at a TCF faces additional man-machine interface complexity with the advent of automated testing systems which presents a manual and automated mixed mode of operation. In addition, the mix of analog Frequency Division Multiplex (FDM) systems and the evolving digital Time Division Multiplexing (TDM) systems presents a mix media situation at the TCF that must be handled by the Technical Controller. With this evolution and sophistication, upgrade of the transmission systems the Technical Control Facility still remains a manpower intensive manual operation.

ES. 3 APPROACH

The following methodology was used in developing this report:

- Identification of functions and tasks performed in a Technical Control Facility and Patch and Test Facility.
- Identification and analysis of those functions that should be automated through a switched facility.
- Investigation and analysis of both commercial and government existing automated technical control systems.
- Identification of a representative number of candidate commercially available switching systems and matrices
- Application of TCF and PTF functional requirements to available switching technology.
- Basic cost comparisons between available switching equipment (analog and digital).

This approach is illustrated in Figure ES-1.

ES. 4 CONCLUSION

It became obvious from the study and analysis of functions performed particularly at a Technical Control Facility and in some cases at a Patch Test Facility that automation of the manpower intensive patching requirements used for testing and circuit restoral could provide a cost benefit. The benefits derived from an automated switch approach replacing present manual patching techniques was present in O & M Cost Savings and significantly increased efficiency of the facility. This automated approach would also allow for centralizing system or network control functions and providing unmanned control facilities. The unmanned control facilities would provide all the required functions on an automated basis and be controlled remotely through access from a centralized TCF. The centralization of system or network control functions would provide additional significant O & M Savings.

Through the analysis of TCF and PTF functional requirements for automation it became apparent that the following design characteristics and architectural structure would have to be provided or

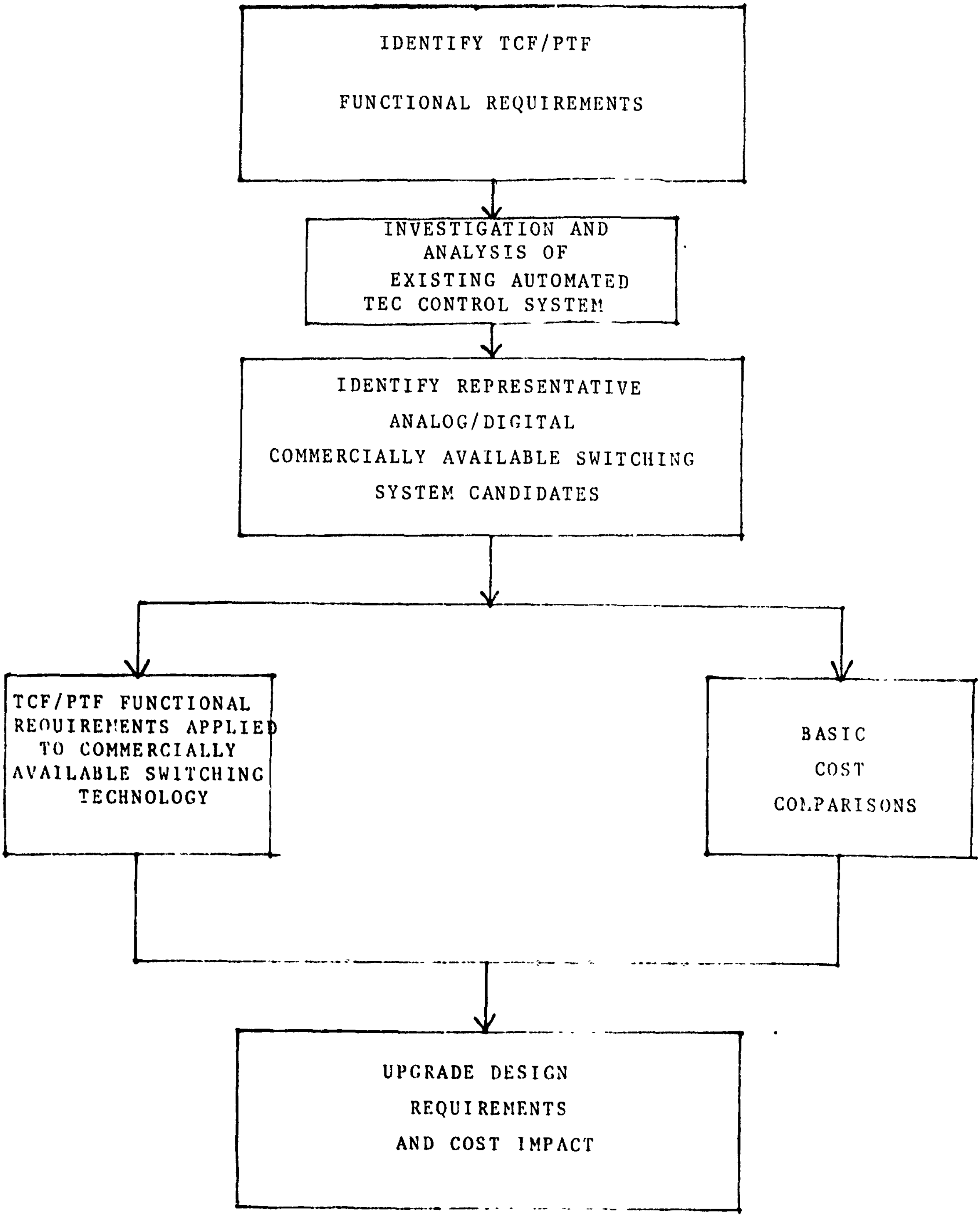


Figure ES-1. Methodology for the Report Development obtainable in any candidate switching system.

Switching of circuit paths (on an individual path control basis)

Nailed-up connections

Circuit access for testing

Pre-programmed alternate re-routing (for maximum efficiency)

Pre-programmed terminations (for maximum circuit utilization)

4 wire switched network (with 4 wire line and trunk circuits)

Non-blocking switch network

The candidate switching matrix would have to be capable of performing these functions without degrading system performance (switch network and call processing).

The switching system would have to provide the following call up connections (circuit paths).

Nailed-up connections	(full period termination with pre-programmed alternate routing if required)
Stored Program Control	(Control of matrix on network by a stored program and data base of a supporting computer)
Test Bus	(Through processor controls, access to circuits via test bus would be provided)

An investigation and analysis of both government and commercial "so called" automated technical control systems was conducted. These systems provide for the automation of testing and recording of parameters. They do not meet the requirements for automating circuit patching functions. These automated testing systems could be used effectively under the control of the TCF/PTF switch, or be jointly controlled with the TCF/PTF switch by a remotely located computer.

The analysis of existing automated TCF systems clearly identified the need to look into the application of commercially available switches and matrices in meeting the automated circuit path requirements of a technical control facility and patch and test facility. This analysis included commercially available analog and digital switching equipment.

Upon applying the functional requirements and assessing the cost impacts to analog TCF/PTF it was determined that a limited availability, electro-mechanical computer controlled matrix would be most cost effective where no conversion to later digital transmission media is planned. Certain limitations, as described in Section 4, are associated with this approach. A hybrid digital/electro-mechanical system is recommended as the most technically adequate where future conversion to digital transmission systems are anticipated.

Computer controlled electro-mechanical metrices are recommended for replacement of digital K,D, and M patch modules as described in Section five.

FUNCTION	STORED PROGRAM CONTROL (SPC) DIGITAL		SPC ANALOG METALLIC MATRIX		SPC ANALOG TDM/PAM	
	HARDWARE	SOFTWARE	HARDWARE	SOFTWARE	HARDWARE	SOFTWARE
SWITCHED CIRCUIT PATHS	A	A	A	A	A	A
NAILED UP CONNECTIONS	A	A	SWITCH NETWORK UPGRADE	UPGRADE	SWITCH NETWORK EXPANSION (ON SYSTEMS OVER 64 CONNECTIONS)	UPGRADE
CIRCUIT ACCESS FOR TESTING	SPECIAL CIRCUITS	UPGRADE	SPECIAL CIRCUITS	UPGRADE	SPECIAL CIRCUITS	UPGRADE
PRE-PROGRAMMED ALTERNATE RE-ROUTING	A	A	A	A	A	A
PRE-PROGRAMMED TERMINATIONS	A	A	A	A	A	A
4W SWITCHED NETWORK	A	A	SWITCH NETWORK EXPANSION NOTE 1	UPGRADE	A	A
4W LINE AND TRUNK CIRCUITS	A	A	A ON SOME SYSTEMS UPGRADE IS REQUIRED	UPGRADE	NEW LINE CIRCUITS	UPGRADE
NON-BLOCKING SWITCH NETWORK	A ADDITIONAL MINOR HARDWARE ON SOME SYSTEMS	A MINOR UPGRADE ON SOME SYSTEMS	SWITCH NETWORK EXPANSION NOTE 1	UPGRADE	UNATTAINABLE ON LARGE SYSTEMS USING MULTIPLE TIME MODULES	

A - Available Within Basic Design

NOTE 1: Could double the cost and size of the switching system.

Figure ES-2. Switching System Upgrade Comparisons

SECTION 1 - INTRODUCTION

1.1 GENERAL

Traditionally, the Technical Control Facility is the focal point of communications system(s) in which all circuits derived from those systems appear. The Technical Control Facility is equipped with patching facilities upon which all circuits appear to allow the Technical Controller to perform their primary function of circuit control, testing, and restoral.

Present day Technical Control Facilities (TCFs) and Patch and Test Facilities (PTFs) are cumbersome facilities that were designed to support a particular system or systems. As new systems were added or old systems expanded the TCFs were added to without benefit of formal design. This resulted in little standardization and created some problems.

An excellent example is the Station Technical Control provided at the AUTOVON Switch installation. Since they were designed to support the AUTOVON Switches, additional facilities were required to control the supporting Transmission System. The result was a duplication of patching fa ilities that added to the already numerous problems that f technical controllers. This type of installation added anothei facet to signal level control in that three separate patching facilities appeared in the control at three different signal levels including the "equal" level patch panels.

In other present day facilities, much the same problem exists. Various types of both audio and dc patch panels were installed. In many cases, audio and dc circuits appear on the same panels, sometimes without effective shielding. This lends itself to locally generated interference, crosstalk, intermodulation, and fortuitous distortion which becomes cumulative and affects the entire system.

This plethora of patching facilities, even within one control facility, contributes in a noticeable degree to the degradation of military communications and lends itself to personnel errors, unnecessary time consumption, and general dissatisfaction of subscribers or users of the communications system, many of whom have critical Command and Control functions to perform.

The purpose of this document is to study and recommend alternatives to the manual patching functions described in paragraph 1.4.2 which will improve the accuracy and speed of patching operations, provide buses for test access, and as an added benefit, reduce manpower requirements.

1.2 O & M FUNCTIONS

1.2.1 Technical Control Functions

The function of the Technical Controller is essentially to assure the provision of efficient and effective communications to system users or subscribers. In fulfilling this responsibility, the Technical Controller duties are to perform:

- Systems tests on a scheduled basis
- Quality Control tests as scheduled
- Accept trouble reports from users
- Coordinate with subscribers and connected or remote technical control facilities to test and restore services
- Utilize appropriate fault isolation techniques on circuits reported in trouble
- Utilize appropriate test equipment to isolate faults
- Make such patches as are required in the testing of circuits
- Make such patches as are required to re-route circuits to restore service

- Perform any action required to reconstitute systems
- Direct corrective actions required for equipment restored locally and at remote sites
- Maintain operational control over local operations personnel in the terminating communications facilities
- Maintain direction of the activities of connected or remote Patch and Test Facilities
- Test new circuits to required specifications and turn-up for service
- Submit operational reports as may be required through command channels
- Submit status reports to the DCA and command channels as required by current directions

1.2.2 Maintenance Functions in Support of Technical Control Functions

The maintenance function performed at Technical Control Facilities include:

- Response to Technical Control directions for repair action
- Perform preventative maintenance routines
- Perform repair actions on local equipment such as radio, multiplex and circuit conditioning modules
- Respond to Technical Control requests for dispatch to remote sites for maintenance action
- Install new circuits as required
- Coordinate with Technical Control on system tests and repair action
- Prepare for shipment and ship equipment to higher level maintenance activities for repair
- Perform such reporting activity through DCA and command channels as required by current directives
- Perform such other functions as may be required by local and parent command directives and procedures

1.2.3 Patch and Test Facilities

Patch and Test Facilities perform some of the same functions as the TCFs. Their capability is greatly reduced as is the number of control type actions they are capable of performing. Basically, they are subordinate to adjacent Technical Control Facilities and if manned, are manned with maintenance technicians who perform a monitoring function, make test measurements, and where possible, perform some patching at the request of the Technical Control Facilities. Probably the best definition of a PTF is "a facility having limited Technical Control Functional capacity, generally manned by maintenance technicians on an "as-required" basis. An exception to this definition is perhaps the AUTODIN control facilities. Though categorized by DCA as Patch and Test Facilities, the AUTODIN Switches are equipped with a Technical Control Facility and these are manned by Technical Control Technicians. The basic difference being that the AUTODIN transmission media is usually routed through a Primary Technical Control Facility; therefore, the AUTODIN controller is basically concerned with the AUTODIN Switch Equipment, encryption devices, and stored program maintenance.

1.3 BACKGROUND

A Technical Control Facility is defined as that specially configured part of a communications system containing:

a. Necessary distribution frames

b. Patch Panels, jacks, and switches

c. Circuit monitoring capability

d. Test and circuit conditioning equipment

e. Alarm indicators

f. Orderwire communications.

The facilities listed above enable the Technical Control personnel to:

a. Exercise essential operational control over communications paths and facilities

b. Perform operational and maintenance functions

c. Detect, recognize, and correct deteriorating conditions

d. Restore disrupted communications

e. Provide requested on-call circuitry

f. Take or direct such actions as may be required and practical to insure fast, reliable and secure defense information

g. Submit operational and status reports through appropriate channels

Technical control facilities were established within the Air Force in the late 1940, early 1950 time period. The basic communications concept of the time was the establishment of a series of Communications Nodal points around the world, at, or close to the equatorial line, yet in appropriate geographical location to support the Air Force mission. Technical Control Facilities were established at these nodal points. In that era, the primary transmission media was High Frequency (HF) radio systems including single channel Radio Teletype (RTTY). One other HF system frequently used provided 4 low speed teletype channels on one radio path utilizing Time Division Multiplex Telegraph Terminals. These systems were designated as Beltline Stations and formed the basis of the USAF GLOBECOMM System which was to evolve into the USAF AIRCOM system and ultimately coupled with communications facilities of the other services into the Defense Communications System of today.

1.3.1 Evolution

While the evolution of communications systems brought more and more sophistication to the transmission media, Switching Systems and the terminal equipment, there was little change in the Technical Control Area. The technical controller has had to contend with the more sophisticated systems and terminals and the resultant demand for higher quality circuits using the same basic patching facilities, little if any built-in test equipment and only slightly enhanced/improved mobile test equipment. The trend to automation in Communications Systems and Terminals has not yet developed in the Technical Control Facility. Here, the controller is faced with the same old techniques of manual patching, manual testing, manual fault isolation, and manual construction and transmission of a multitude of reports both administrative and operational.

It can readily be seen from the above that despite the best effort of extremely dedicated and efficient personnel, the Technical Control Facility is in fact one of the most vulnerable segments in the system. Because of its addiction to manual functions in all areas, it is manpower intensive, prone to delays, inhibits the rapid flow of communications interchange and is subject to numerous personnel errors.

While this report is directed towards the study of alternatives to manual patching, the state-of-the-art makes it imperative that other functions of the Technical Control and Patch and Test Facilities be addressed as well. Of particular concern is the testing of and access to circuits for test and restoral purposes. This requirement alone dictates that some form of automation in Technical Control Facilities be addressed.

1.3.2 Automation of Technical Control

At various times in the past, there have been limited efforts towards automation. In the Air Force, the "Quick Fix" program was among the first. The latest effort has been the Automated Technical Control (ATEC) Program. While this may be an effective program, it is limited in scope, being applicable to only a few facilities. ATEC is essentially a misnomer in that it does not truly automate the Technical Control Facility but rather provides only certain test measurements automatically to the Controller at a central node point. It still remains a manual function for the controller to act upon the readings received, perform fault isolation, reroute the circuit to restore service, and to direct a maintenance activity to take remedial action necessary to restore the original path.

It is clear, therefore, that it is imperative to develop a more automated system of Technical Control to keep pace with the rapid advancements being made in today's communications systems

1.3.3 Commercial Control

The commercial world has evolved even more rapidly than the military in their communications system. This can be understood when it is realized they are motivated not only by improved service but also to the profits involved by providing such service. To meet the need for improved service they have introduced many forms of automation into their operations. Obviously, a switch in the commercial world forms the basis for a means of connecting one subscriber to another rapidly and accurately while at the same time reducing the number of permanent connections to that of the subscribers access line to a central office or PABX. Ancilliary to this, the commercial telephone companies have introduced several automatic features that enable their craftsmen to maintain a reliable data base, perform such tests as are required to maintain reliable service, provide automatic alternate route capability, and the capability of automatic control of support functions such as power, security and environmental protection.

1.4 CONTROL CONCEPT

1.4.1 Manning

Paragraph 2.1 and 2.2 outline the generally accepted functions of a Technical Controller and Maintenance Technicians in a communications station. To perform those functions the typical Technical Control Facility manning is based upon the number of circuits appearing in the particular control facility. Actual numbers are based upon a formula contained in AFCC manning documents. There are generally three sizes of Technical Control Facilities, categorized as small, medium, or large. Small control facilities are usually manned by as few as five personnel whereas large control facilities may be manned with 50 or more controllers.

The skill level of the Technical Controller is of particular concern and efforts are made to maintain a balance between 30730 Attendant/Specialist, 30750 Specialist, and 30770 Technician skill level. In larger controls, the Superintendent positions are generally filled by an E-8 or E-9 at the 30790 Superintendent level and at small and medium controls the Superintendent authorization is usually filled by an E-6 or E-7.

One of the major problems confronting the Air Force in common with other Military Services is maintaining proper balance in the skill level of control personnel and the retention of skilled personnel. As an example, it is not uncommon to find a control facility manned at 400% of authorized manning at the 30730 Attendant level, 75% manned at Specialist 30750 level and as little as 45 % manned at the 30770 Technician level.

It can readily be seen that the manning for Air Force technical controls is extremely critical and remains almost constantly so. The functions of the controller are also basically constant but the workload frequently expands as new systems and new types of systems are added to the Air Force inventory. At the point when the Airmen are considered well qualified and technically competent to accept additional responsibility both in job performance and training subordinate personnel they tend to leave the Air Force for more attractive opportunities in the commercial market place. This manning issue is mentioned in light of the need to automate and be able to accomplish the technical control functions more efficiently.

1.4.2 Technical Control Functions

The functions performed by the Technical Controller are listed in paragraph 1.2.1. They are expanded here to illustrate the manpower intensiveness of the Technical Control Facility.

a. Systems Tests on a scheduled basis.

   These are performed by a controller at least once each day on several channels of each system terminating in the Control Facility. Additionally, Baseband level measurements are taken as well as Receive Signal Levels. These tests involve the time of one technician at the other end of the circuit/channel to provide terminations and level measurements. In addition, time is expended to convert the readings taken to an appropriate report format, write the report, and prepare the report for transmission.

b. Quality Control Tests as Scheduled.

   To conform to DCA Criteria, all circuits terminating in a Control Facility are Quality Control (QC) Tested on a quarterly (from date of installation)basis. This involves removing the circuit(s) from service and providing a restoral path for the subscribers use during the test period if a spare is available. If an alternate route is not available, a user release must be obtained. Once the circuit is taken for QC, a number of tests must be performed depending on the type of circuit.

These tests include frequency response, signal level, envelope delay, terminal impedance, longitudinal balance, single tone interference, harmonic distortion, impulse and idle channel noise, phase jitter and frequency change. Depending upon the type of test equipment available, usually manual, these tests take an average of 2 hours to perform and can take longer if an inexperienced person is involved, or if a fault is found which requires correction and retest. Again, appropriate reports must be filed and records maintained.

c. Accept Trouble Reports from Users.

As implied, this involves accepting calls from users and involves completing a trouble ticket with all applicable information including time, trouble indication, circuit identification, operator initials, etc. Time required for this function is variable and is usually less than five minutes per report.

d. Coordinate with Subscriber and Connected or Remote Technical Control Facilities to Test and Restore Service.

This involves the test of spare channels to identify an alternate route path after an outage occurs and patching to the new path. It requires coordination with the distant end and possibly intermediate controls depending on the path of the alternate route. The time involved in completing the altroute is dependent upon the complexity of the circuits. It is generally not less than 30 minutes unless it is a direct circuit between only two controls. Again manual operational reports are required.

e. Utilize appropriate Fault Isolation Techniques on Circuits Reported in Trouble.

This is one of the primary functions of the controller. It involves coordination with the controller at the distant end or the intermediate path. It may involve coordination and testing with a commercial carrier if they provide all or part of the circuit and also with the user of the circuit. It involves the use of a variable quantity and type of test equipment and requires extensive time to make the various tests.

Total time taken to accomplish trouble shooting, identification of fault, repair and restoral may take any length of time from 15 minutes to several hours. Information garnered from this procedure is also required to be formatted and reported to appropriate agencies.

f. Utilize appropriate test equipment to isolate faults.

As implied this requires the use of various types of test equipment to identify trouble source and location on a circuit. It requires extensive knowledge of both test equipment and circuitry. The time involved may be minimal or extensive dependent upon the extent of the problem.

g. Make such patches as are required in the testing of circuits.

This involves quite an extensive patching function. First in rerouting the circuit when possible and repeatedly in connecting various pieces of test equipment to the circuit under test. While the time involved in actual patching is miniscule, considerable time is expended in performing the various tests

h. Make Such Patches as are Required to Reroute Circuits to Restore Service.

This involves patching of spare equipment to lines or original equipment to spare lines. It may also involve group patching in the Multiplex Area. The time involved in actual patching in this situation is minute but additional time is required to accomplish any necessary realignment and to report action taken.

i. Perform any Action Required to Reconstitute a System.

While this is an infrequent requirement, it is probably the most complex. It would probably involve interfacing with a Tactical System with all the inherent difficulties involved including siting, patching, testing, and alignment. No time period can be identified for accomplishment.

j. Direct the Performance of Maintenance Personnel Locally and at Remote Sites.

This function really ties in with the majority of other functions. For example, in the process of fault isolation, it frequently happens that a fault is isolated to a piece of station equipment which must be turned over to an appropriate maintenance technician for repair. The time involved is variable depending upon the complexity of the problem.

k. Maintain Operational Control Over Local Operations Personnel in the Terminating Communications Facilities.

This involves cooperation and coordination with traffic personnel in maintaining continuity of traffic flow, providing additional circuits as required, passage of traffic data between communications centers, etc. The time involved is variable.

l. Maintain direction of the activities of connected or remote Patch and Test Facilities.

This is a critical function important to the continuity of the overall system. For example, it generally involves coordination with personnel at telephone central office centers whose personnel are not familiar with long distance communication or control procedures.

It also involves coordination with personnel at repeater sites that are critical to the operation of a system usually being an integral part of the system of concern. The time spent on this activity is also variable and is added to by the requirement to prepare DCA reports for those facilities as a "reported on" station.

m. Test new circuits to required specifications and turn-up for service.

This involves patching test equipment to newly installed circuits to make necessary parameter measurements to insure that the circuit meets DCA specifications. Generally speaking the time required is equivalent to that required for QC measurements, an average of two hours.

n. Submit operational reports as may be required through command channels.

This involves a undetermined number of reports which the controller may be required to submit in addition to the operational reports previously discussed. Generally they involve reporting on special interest circuits, explanations of extended circuit/systems outage, status of new installations or any like subject. Specific time requirements are unavailable.

o. Submit status reports to the DCA and Command Channels as required by current directives.

This involves the submission of circuit/system status information to DCA Operation Centers and Command Management Offices on both an as occurs basis and a scheduled basis. It includes link assessment reports, outage reports, re-route and restoral reports and hazardous condition reports, etc. All of these report requirements are time consuming to prepare because of the prime requirement for accuracy. Time required to prepare and process these reports depends primarily on the number of reportable events that occur each day.

In addition to the functions outlined above, it is usual for one controller to be assigned as "Circuit Manager." It is his function to process Telecommunications Service Request, Telecommunications Service Orders, process "in-effect" or "exception" reports, maintain a circuit history file and be current on all circuit actions within the facility. This is a full time duty hour position frequently involving overtime.

The Superintendent or Non-Commissioned Officer in Charge (NCOIC) of the facility is responsible not only for the effective operation of the control facility, he must be prepared to provide technical assistance to subordinates as well as attend to the myriad of Administrative and Personnel details that arise. This is a time consuming process frequently taking up more than the duty day.

1.4.3 Technical Control Operations

The preceeding paragraphs have outlined the functional description of a technical control facility, defined the functions of the control operation and provided a general overview of the background and history of technical control facilities, its manning and concept.

The actual operation in a technical control facility follows that outline very closely. Almost without exception, every action taken in a technical control facility is manpower intensive. Every test performed requires one or more patch. Every patch is a manual function. Every test performed requires manual operation to a greater or lesser degree. In some facilites new test equipment has been made available which automatically performs some of the test functions but, while this is true, a manual action is required to connect the test equipment to the circuit under test. Quality Control testing comprises probably 30% of the control workload and all of this testing is a manual function.

Numerous reports are required to be submitted to various agencies. This is a manual operation which consumes an extensive amount of time on the part of the controller, that time could be better spent in learning or in training subordinate controllers.

Almost all of the functions a technical controller performs are duplicative. This is true in the sense that most functions are performed each shift (though possibly on different channels) and in the sense that at the other end of the circuit another technical controller is acting in concert with him in testing the circuits. This follows the traditional methodology that each control is responsible for the "receive" side of the circuits.

Alternate routing is a common function of the technical controller and is frequently a lengthy, time consuming process. It is a manual function performed by manual patching to provide temporary service and usually after lengthy coordination to establish and test a path for use.

1.5 COMMERCIAL FACILITIES

In the commercial world, switching centers serve as the focal point of the telephone/data communications network both in the Bell System and in the Specialized Common Carriers such as Southern Pacific, MCI, and USTS. This is true in the provision of service to telephone subscribers both local and toll (Long Distance) and also true in the context of Technical Control. In the Bell System, the Control function is performed from the switching centers but is not identified as Technical Control. It is generally divided into two functions identified as "Repair Services Bureau", which is customer related and "Toll Test Center" which is plant or network related. The military counterpart to these would probably be best described as Technical Control and Radio Maintenance respectively. The military Technical Controller deals directly with the subscriber as does the Repair Service Bureau. The controller also performs the testing function as do the Toll Test Center personnel. The difference being that the Toll Test Center personnel report to the Repair Service Bureau who in turn reports to the subscriber in the same manner that the maintenance section reports to the Technical Controller who in turn reports to or coordinates with the subscriber.

The commercial companies have long recognized the complexity and manpower intensity of the technical control function. Though recognizing the need for automation in the technical control area it has not been cost-effective to implement a large degree of automation until recently. Analog switches which have provided the backbone of the commercial networks are expensive and complex and do not lend themselves to automation. The automation of the control function has generally been in easily sensed but critical areas. Some degree of automation through sensing of signal levels, fuel reserves, security and alarm functions at remote repeater sites telemetered to a central switch for ultimate manual reaction has evolved which makes it possible for control of major segments of the communications network from a central location. For example, at Dranesville, Virginia, AT&T has a computer controlled device which provides monitoring of a total region encompassing the Southern New England area. From this central point AT&T personnel can monitor total system/station failures and take necessary restoral action by rerouting super or master groups automatically over several routes while manual repair action is taken at the local level. Little if any automation is provided for the control of an individual 3 kHz channel. With the advent of digital systems and their associated automatic control devices, such as signal processors and IO devices, more critical control functions can be performed.

During the course of this study it became evident that the best and most viable alternative to manual patching is the introduction of the commercial concept into military systems, particularly as such concepts apply to Technical Control. An automated environment must be introduced with the necessary ancilliary equipment which will enable automation of many of the functions now manually performed by the Technical Controller. While a profit motive cannot be attributed to the military in the same context as in the commercial world, it will nonetheless be profitable in that a considerable reduction in manpower intensive tasks will be realized and consequently an ultimate reduction in manpower requirement will be achieved. Likewise the improved service provided will indeed be profitable to the military community.

1.6 ALTERNATIVES TO MANUAL PATCHING

1.6.1 Non-Switching Automatic Technical Control Alternatives

In an effort to identify a commercial off-the-shelf product that would satisfy all of the requirements for alternatives to manual patching a number of product lines advertised as automatic technical controls or like titles were investigated. They were:

a. The Remote Access Switching and Patching System (RASP) manufactured by Spectron Corporation of Moorestown, New Jersey. It offers many of the desired capabilities as follows:

- Automatic Failures Reporting
- Fault Isolation
- Restoral Capability
- Remedial Maintenance
- Historical Data Logging
- Ease of Reconfiguration.

One advantage of the RASP test stations was that it is applicable to both Analog and Digital Systems. Unfortunately the basic component is a patch panel and this overrides any other advantage since it would not eliminate the need for manual patching.

b. The TTI Switched Access System manufactured by Telecommunications Technology of Sunnyvale, California. Their advertised product indicated that some of the features required were available but they could not meet all requirements. In response to our inquiries they advised that they anticipated further development of a system that would meet the requirements outlined in the SOW. Though not considered adequate now, future developments may be such that reconsideration might be advantageous at a later date.

c. The Network Control System developed and manufactured by Atlantic Research Corporation of Alexandria, Virginia was investigated. This system offers many advantages that would be of value in a small Technical Control Facility or in a Patch and Test Facility. However, like the RASP system it is predicated on a manual patch and test function and does not meet the requirements.

d. The Remote Access System (RAS) developed by ADC Telecommunications of Minneapolis was examined. The RAS 6100 is a modularized, push button control system, which can perform local or remote testing of audio and dc data lines.

It is designed for use with ADC manufactured test boards but it is compatible with other test equipment which performs the same function.

e. The RAS 6300 is a processor controlled version of the RAS 6100 system. Either of these systems appear adequate to meet the requirements except switching capability to restore service or to reconstitute a system. Like many of the other manufacturers ADC anticipates future development of a product which will meet requirements but in an unidentified time frame.

The above examples are representative of the results obtained from our research into alternatives to manual patching. In continuing research, it was determined that the only viable alternative to manual patching is through the use of existing off-the-shelf switching machines or matrices with modifications to enable accomplishment of all required functions. There are several switches presently being successfully used in the commercial world equipped with a variety of ancilliary equipment which would be capable of satisfying the requirements for alternatives to manual patching. The following sections of this report will identify those switches and enumerate their salient features.

SECTION 2 - ALTERNATIVES TO MANUAL PATCHING

2.1 INTRODUCTION

This section includes functional descriptions of the switching necessary to implement Alternatives to Manual Patching as described in the Statement of Work for this task.

2.2 ANALOG TECHNICAL CONTROL CONFIGURATIONS

The configurations of technical controls now in service generally follow the layout shown in Figure 2-1. In this figure, the circuit patch bay equates to the SOW VF Primary Module, and the VF Patch Bay equates to the SOW VF Equal Level Module. The Group Patch Module is not shown as such, but would be found in Figure 2-2 between the Group Mux/Demux and the Super Group Modulator/Demodulator. The Primary Module could require up to eight leads to be switched, four analog (VF) signal and four D.C. signal leads. The VF Equal Level Module would normally require only four (VF) signal lead switching. The Group Level Module would normally require four signal leads switched. Frequencies on these leads are normally found in the 60 to 108 KHZ band.

2.2.1 Concept of Analog Technical Control Switching

Figures 2-3, 2-4, and 2-5 depict a concept of the switching arrangements for two circuits and two groups required to satisfy the SOW for Analog Technical Controls on a limited basis. The diagrams depict only ten crosspoints per switch; however, this limitation is imposed only by the size of the page. The switches could as easily be 60, 120, or 240 crosspoints. The difference being whether or not full availability of all line conditioning equipment is provided to each circuit. This switching arrangement is non blocking.

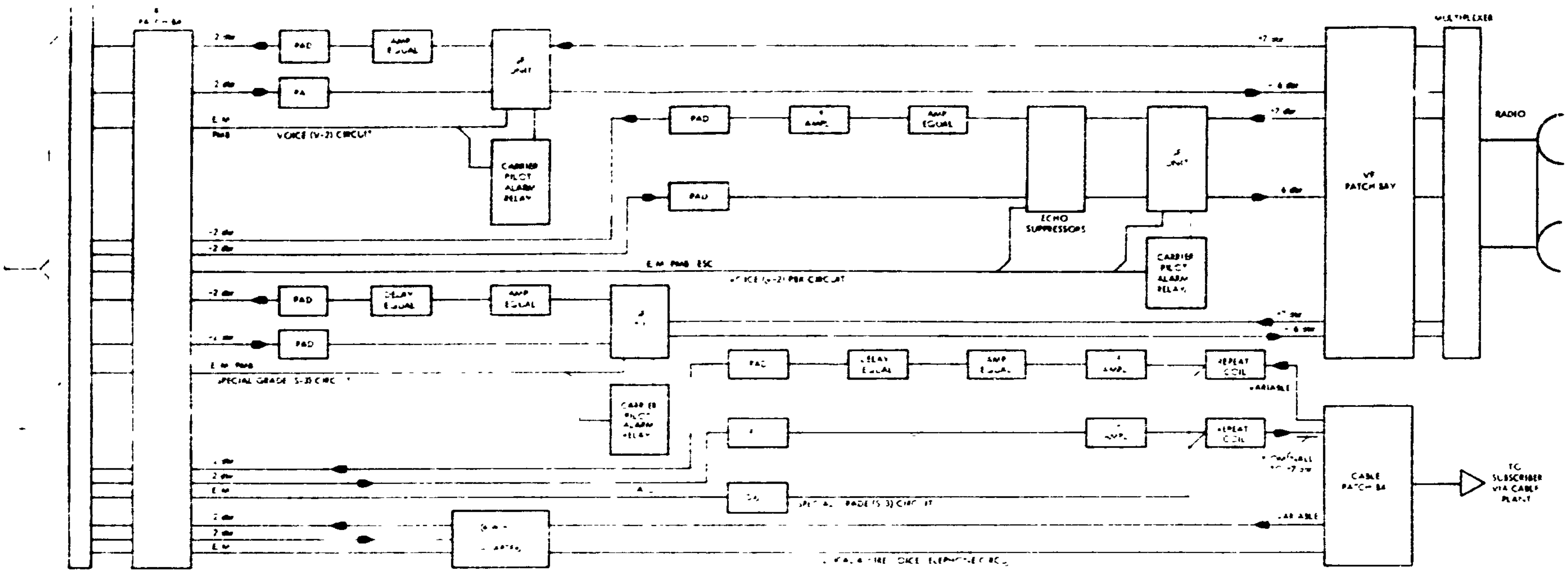


Figure 2-1. Current Analog Technical Control Configuration

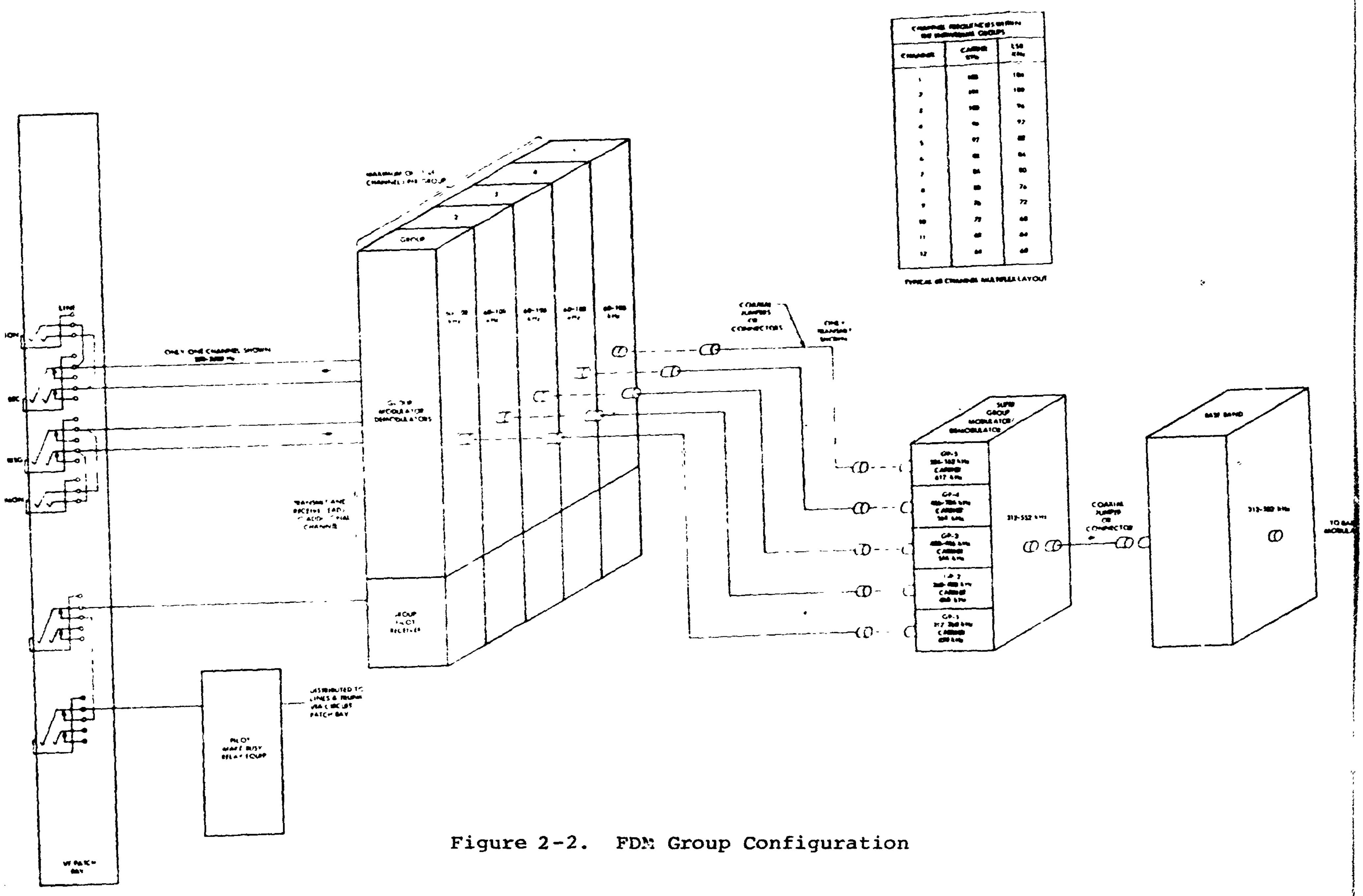


Figure 2-2. FDM Group Configuration

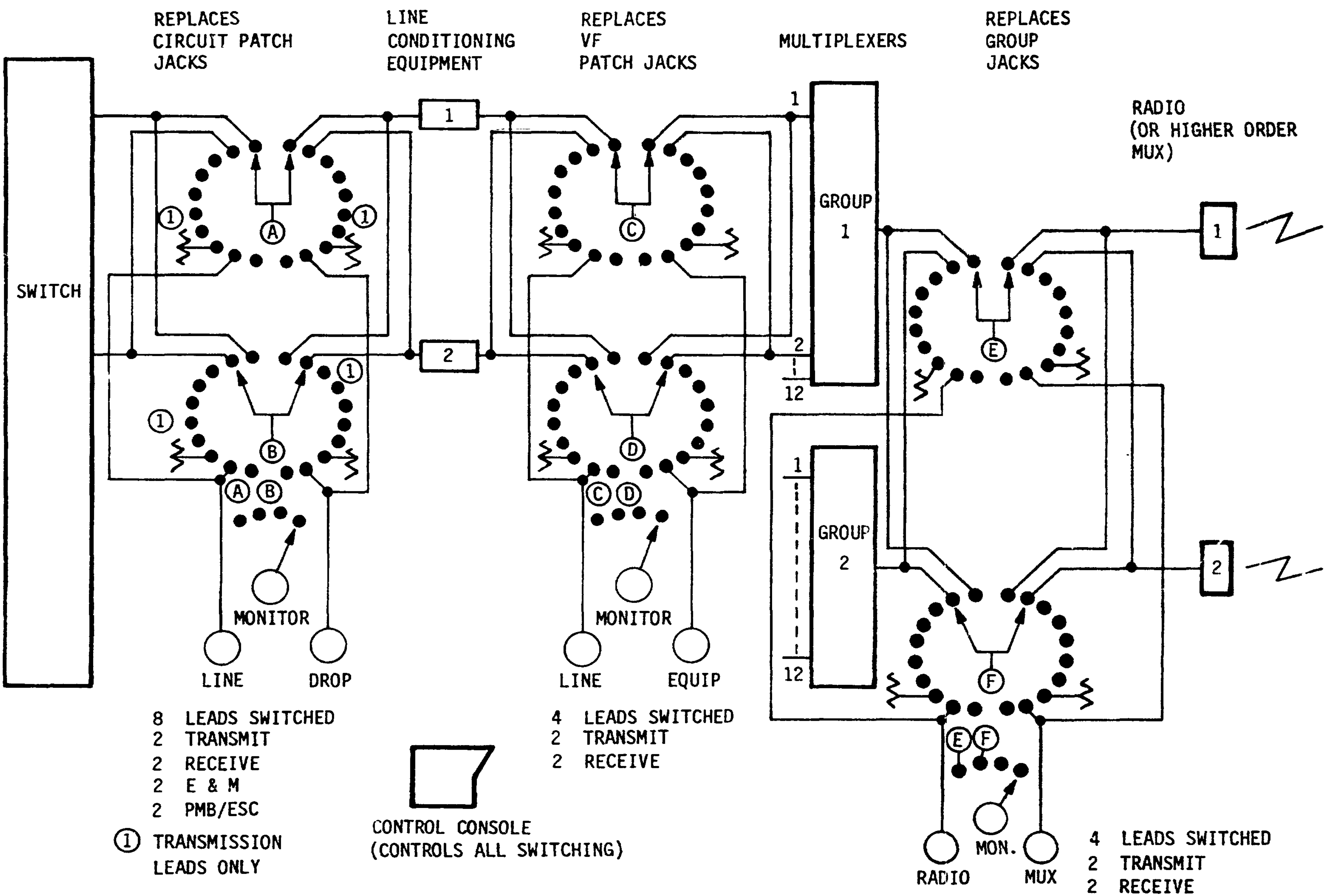


FIGURE 2-3 NORMAL THROUGH SWITCHED CIRCUITS AND GROUPS

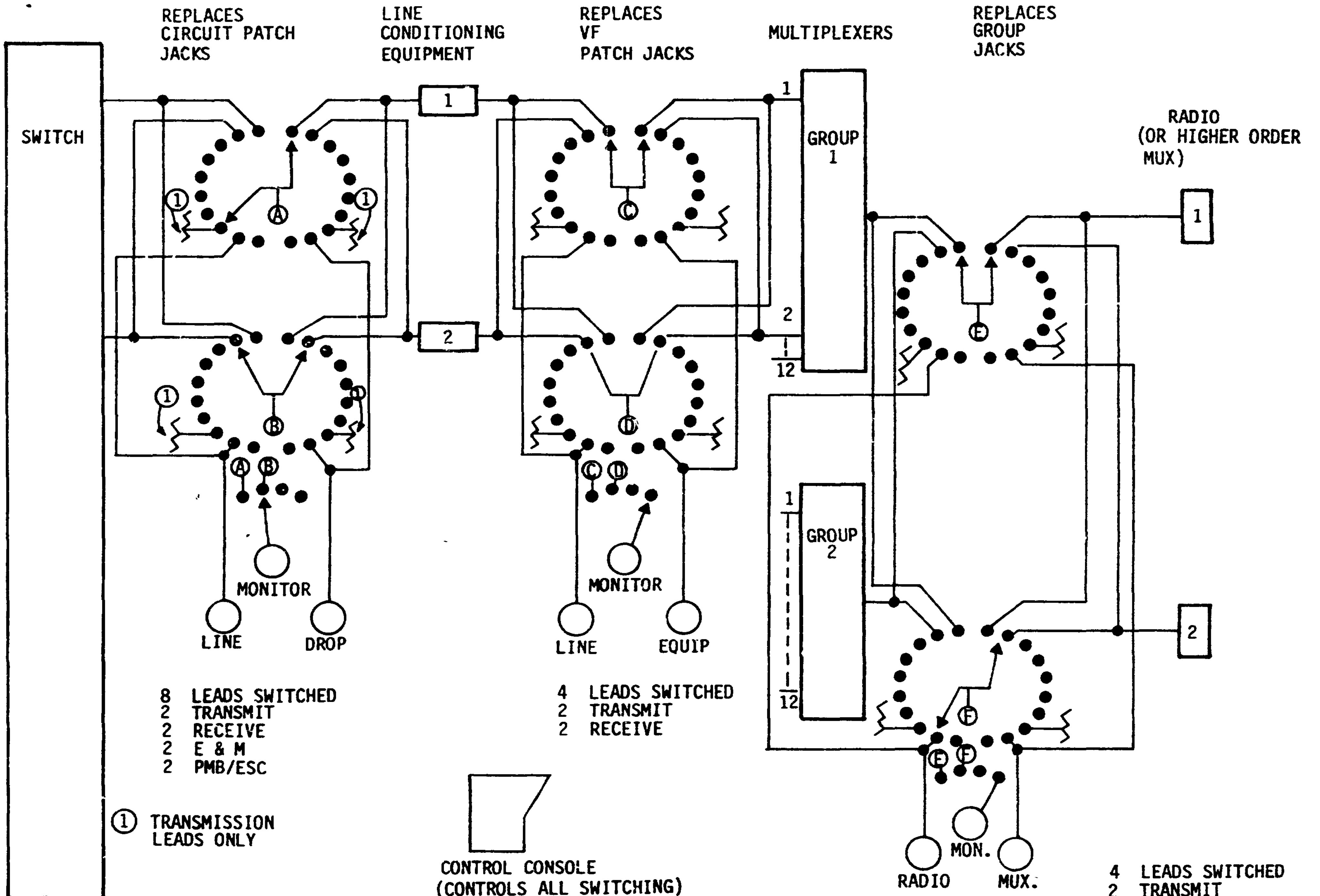


FIGURE 2-4 CIRCUIT AND GROUP TEST CONFIGURATIONS

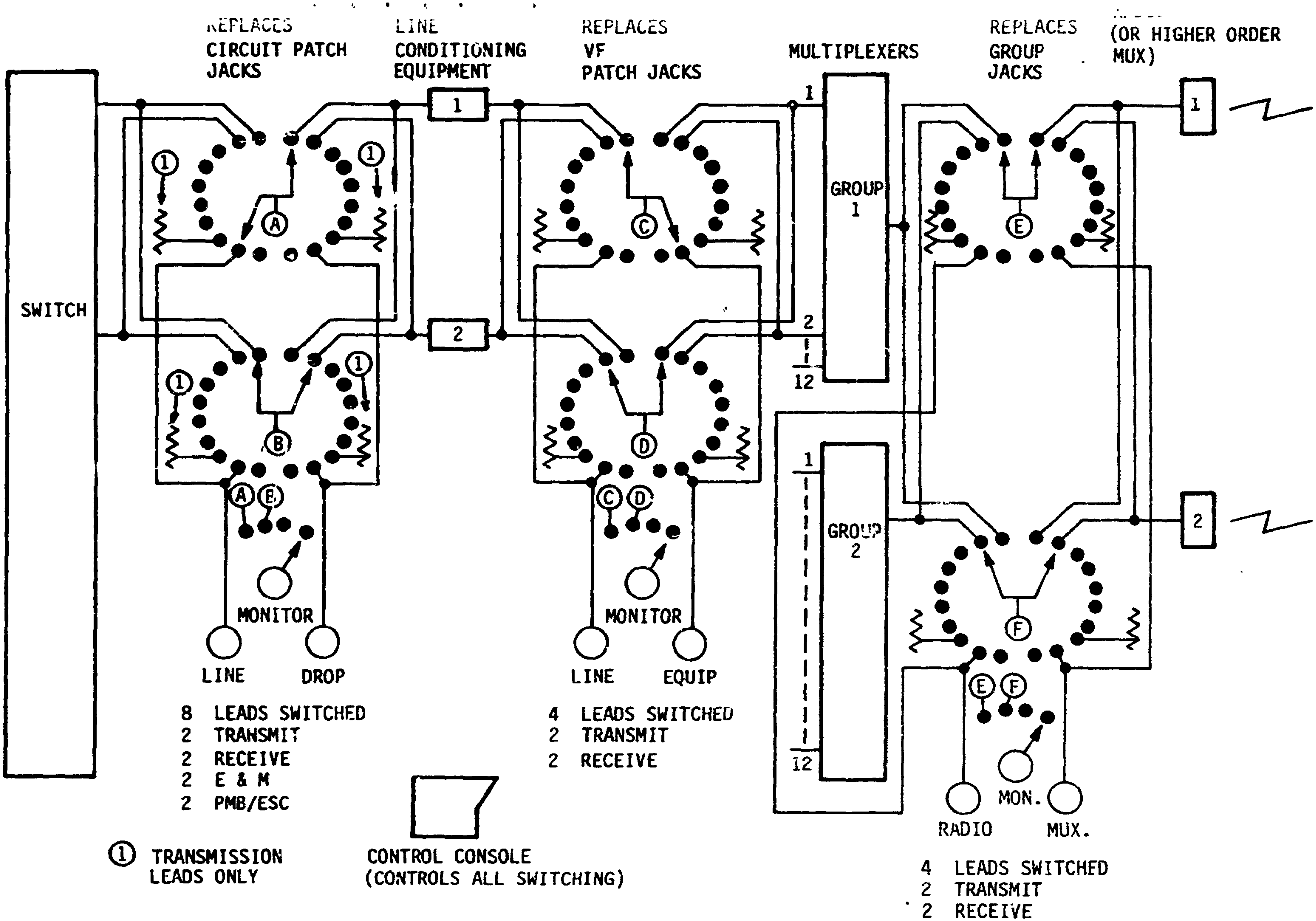


FIGURE 2-5. CIRCUIT TEST AND RECONFIGURATION

Referring to Figures 2-3 to 2-5, the switches on the left side of the page replace the VF Primary Module or Circuit Patch Jacks. As many as eight leads must be switched at this point. Two transmit leads, and two receive leads would always be switched. Switching of as many as four D.C. signaling leads could be required. Each circuit, and each piece of line conditioning equipment at this point has access to a termination and test equipment patch jacks. High impedance moitoring is accomplished via the switch shown with a wiper attached to the monitor jack.

The switch arrangements shown in the center of the figure are identical to those on the left, except the number of leads being switched is only four.

The arrangement at the right of the page performs the same type switching for the group level switching. Figure 2-6 shows the logic now provided with patch jacks at the group level, and which must be provided for at the group level switching point. This termination logic must provide idle circuits with characteristic impedance terminations. These terminations can be provided external to the switching arrangement in the same manner as the termination shown.

2.2.2 Normal Circuit Configuration Concept

In Figure 2-3, both circuits and both groups are shown in the normal through configuration.

2.2.3 Reconfiguration for Measurements

Figure 2-4 depicts circuit #1 terminated at the Primary VF Module for noise or balance measurements by a distant station. Circuit #2 is shown normal through with a high impedance monitor at the Circuit Patch Line Jack and Group #2 is shown connected to the Radio (or Higher Order Mux) jack for measurements over the transmission system to the distant station.

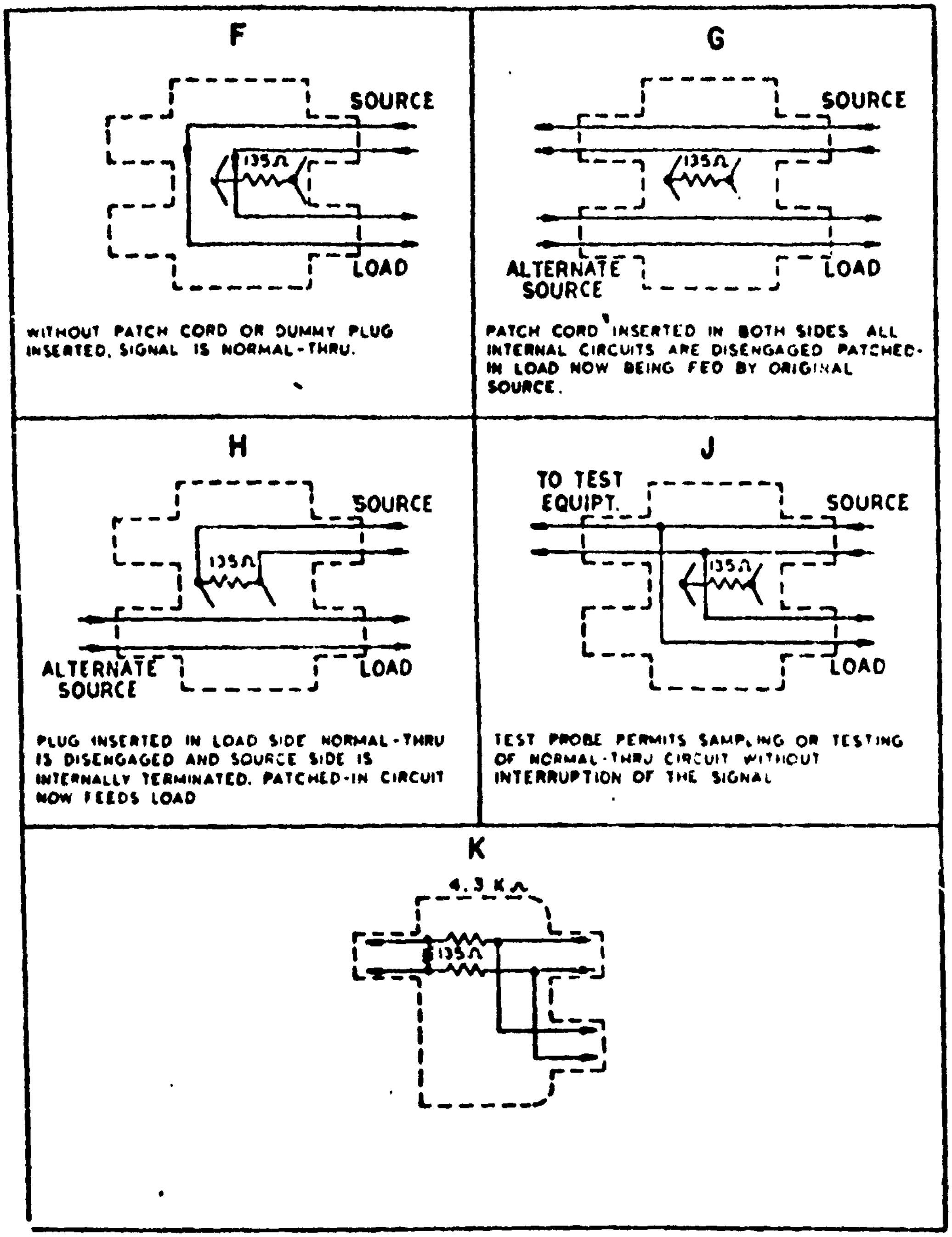


Figure 2-6. Example of group jack logic

2.2.4 Circuit Restoral

Figure 2-5 depicts the normal line conditioning equipment for Circuit #1 configured for test between the Primary VF Line and VF Equal Level Equipment Module jacks. Circuit #1 is restored to service on the line conditioning equipment of Circuit #2. The status of Circuit #2 is not depicted; however, it could be restored on spare equipment (not shown). Groups 1 and 2 are shown normal through.

2.3 D.C. TECHNICAL CONTROL CONFIGURATIONS

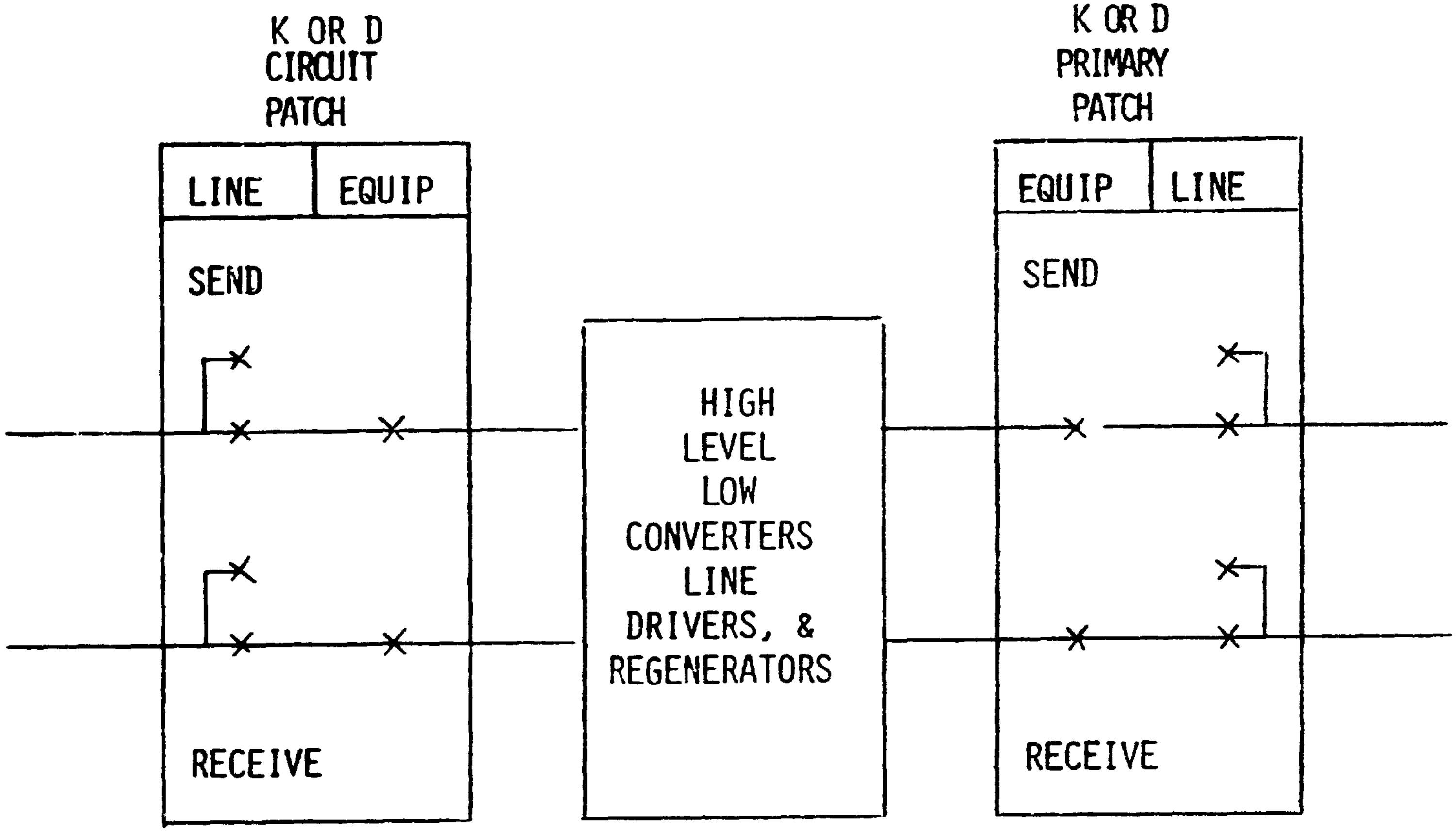
D.C. Technical Control facilities are generally configured as depicted in Figure 2-7. This figure depicts and describes the K and D patch facilities. Patch facilities for M TDM 1-3M-Bit/Second signals are similar to the K or D Circuit Patch facilities. Currently used jack facilities are depicted in Figures 2-8, 2-9, and 2-10.

2.3.1 Concept of K and D Circuit Switching

The switching concept to be employed with K and D switching is shown in Figure 2-11. All circuits are shown normal through; however, switching may be accomplished as with the Primary and Equal Level Modules discussed in Paragraphs 2.2.3 and 2.2.4.

2.3.2 Concept of M Patch Switching of TDM Signals

The concept to be employed for the switching of M Modules is depicted in Figure 2-12. Switching is accomplished as with the group level switching discussed in Paragraph 2.2.3.



K patch facilities are used for balanced signals <1 M-Bit/Second

D patch facilities are used for unbalanced signals <1 M-Bit/Second

M patch facilities are used for balanced low level TDM signals 1-3 M-Bit/Second

Figure 2-7. Manual digital circuit patching facilities, electrical configuration

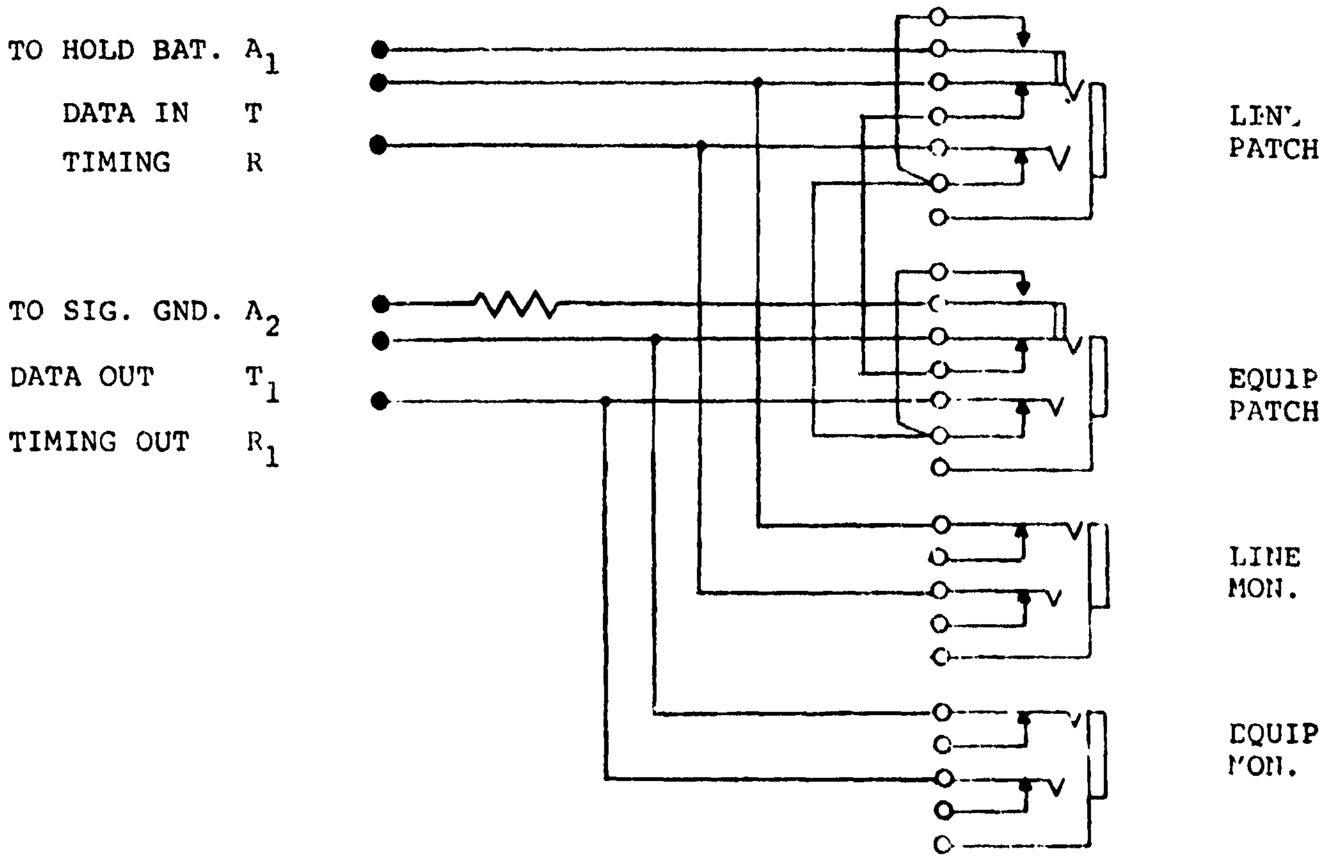


Figure 2-8. Receive high-level digital jackset

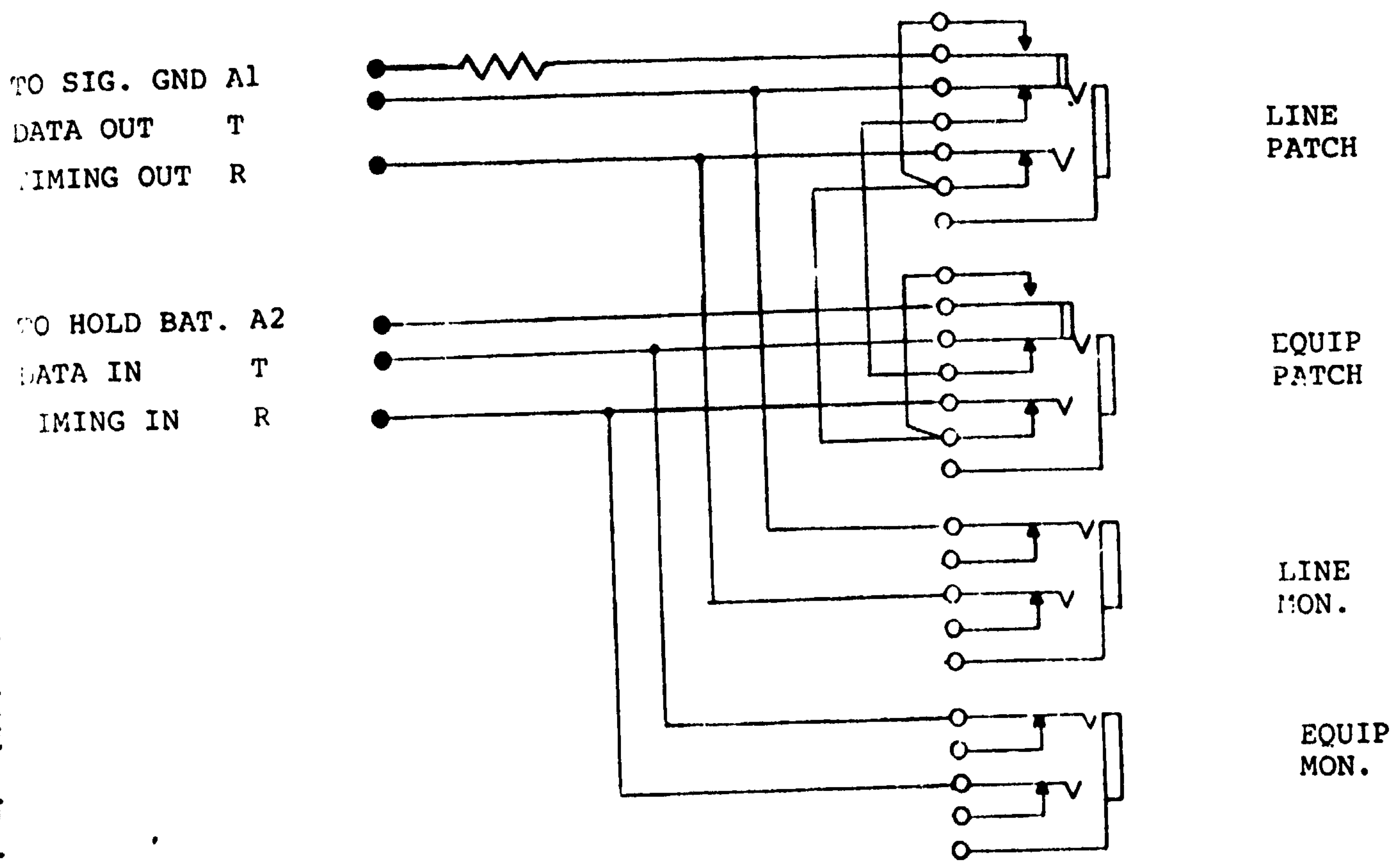
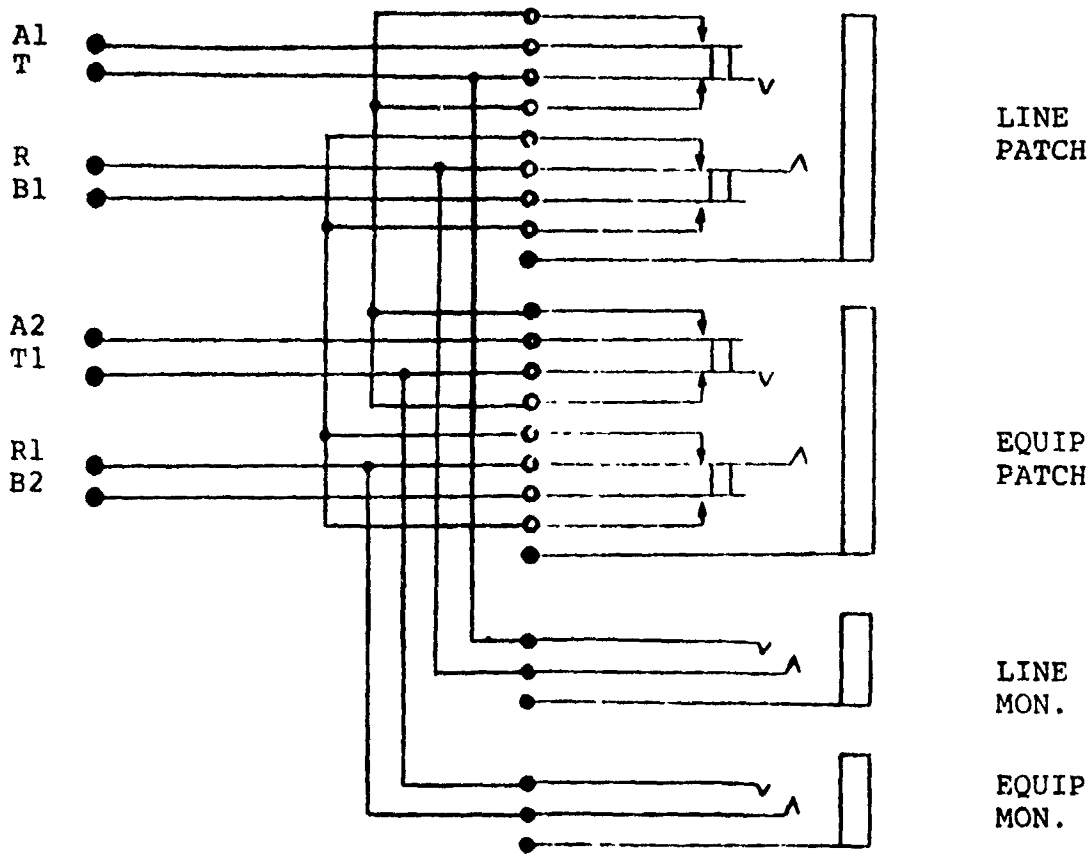


Figure 2-9. Transmit high-level digital jackset



Note: A1 and B1, A2 and B2 are connected to hold battery or termination resistors, as required.

Figure 2-10. Transmit and receive low-level digital jackset

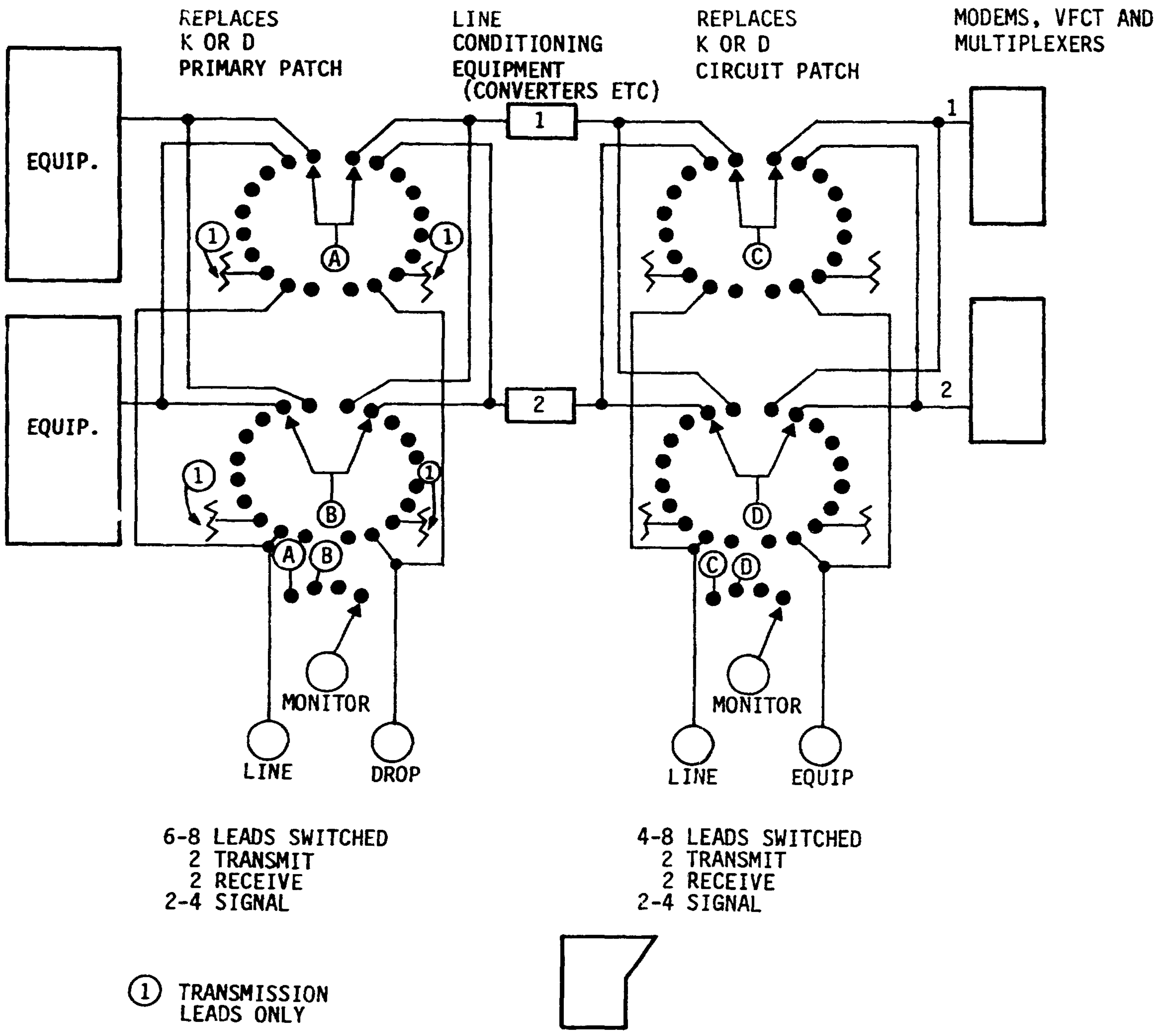


FIGURE 2-11 CONCEPT OF K AND D SWITCHING

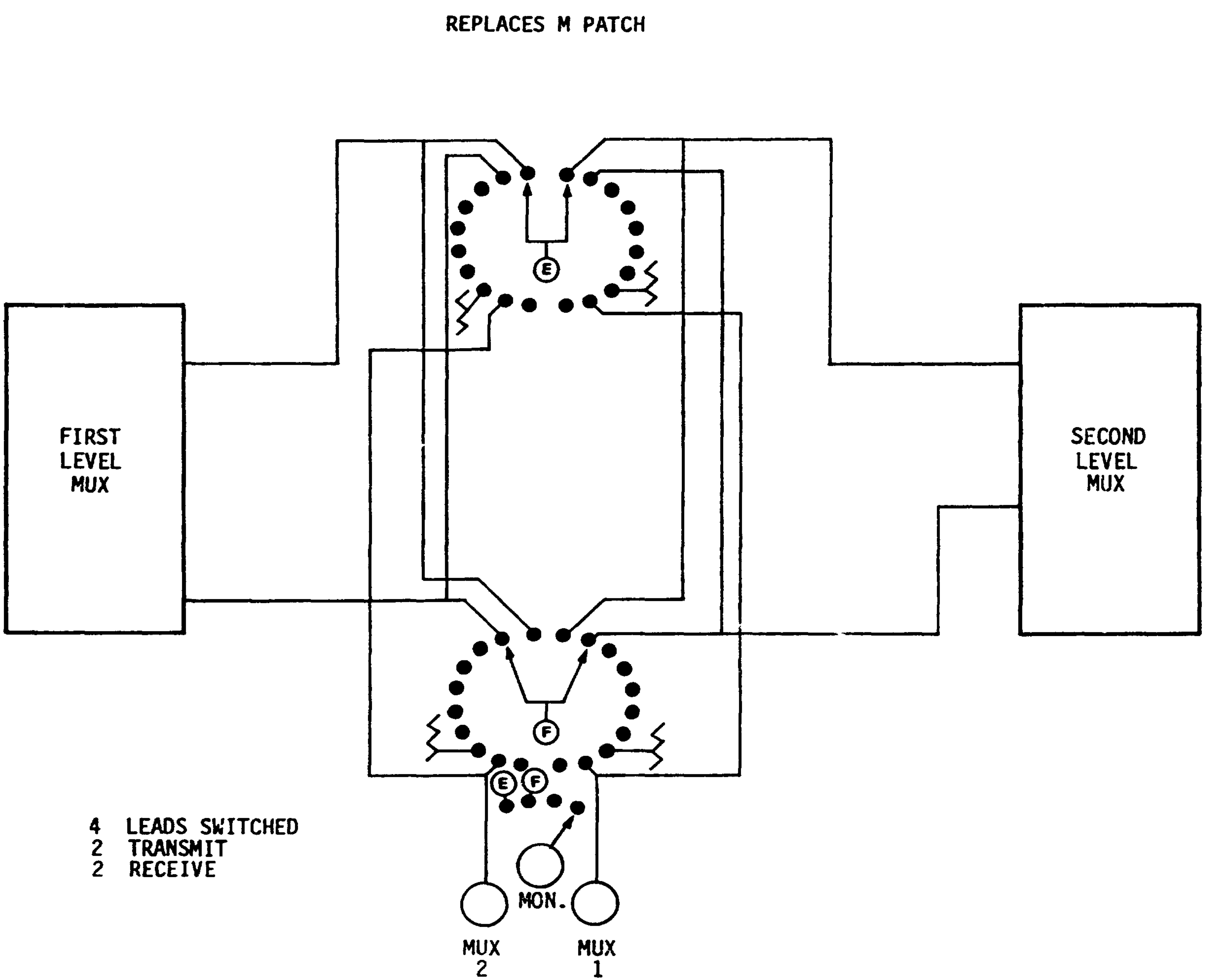


FIGURE 2-12 CONCEPT OF SWITCHING MATRIX TO REPLACE 1-3 MHZ TDM PATCH JACKS

SECTION 3

TECHNICAL COMPARISON OF AVAILABLE ANALOG AND DIGITAL SWITCHES

A survey of equipment manufactured by several companies was conducted. The major telephone switching manufacturers do not manufacture non-blocking matrices, either analog or digital, and their control logic and software are designed for production switching equipment and do not easily lend themselves to conversion to the switched technical control concept. One large switching manufacturer, Wescom, does manufacture non-blocking digital networks, however their control logic and software follow designs similar to that of the other major switching equipment companies.

There are however, analog matrix systems available which can be configured as non-blocking matrices, and which can be controlled by an external processor via a standard computer interface.

There is also at least one manufacturer which provides a modularly expandable digital switch which is non-blocking and controllable by an external processor via a standard computer interface.

3.1 ELECTRO MECHANICAL ANALOG SWITCH CONFIGURATIONS

As a representative sample of the analog matrices available, the products of A. D. Data Systems, Inc. were chosen. These products were chosen also because of their flexibility and modularity. Figure 3-1 shows one reed relay module. The one shown is a three-wire module; however, a four-wire module will be available in approximately six months. Figure 3-2 shows a concept drawing of how a sixty channel full availability, non-blocking matrix can be constructed from these modules. Access is available for test, monitor, terminating and reconfiguration in any configuration of the sixty channels. A similar arrangement for five group switching is shown in Figure 3-3 . Table 3-3 is a cost estimate of a sixty channel, non-blocking, full availability system.

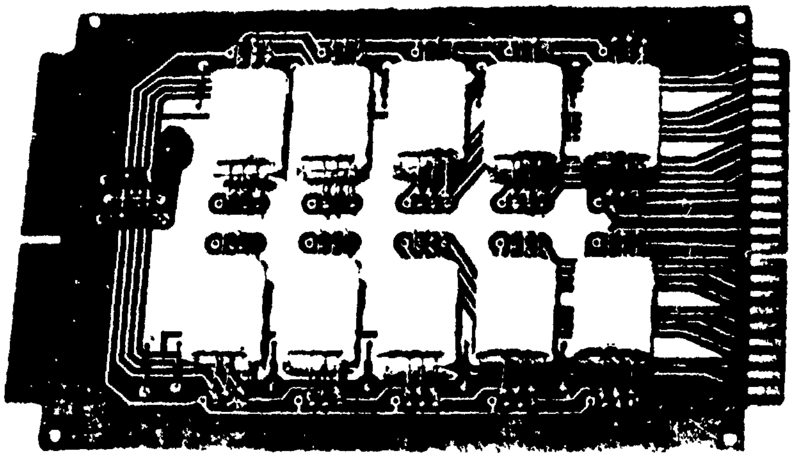


Figure 3-1. Analog Switching Matrix Module

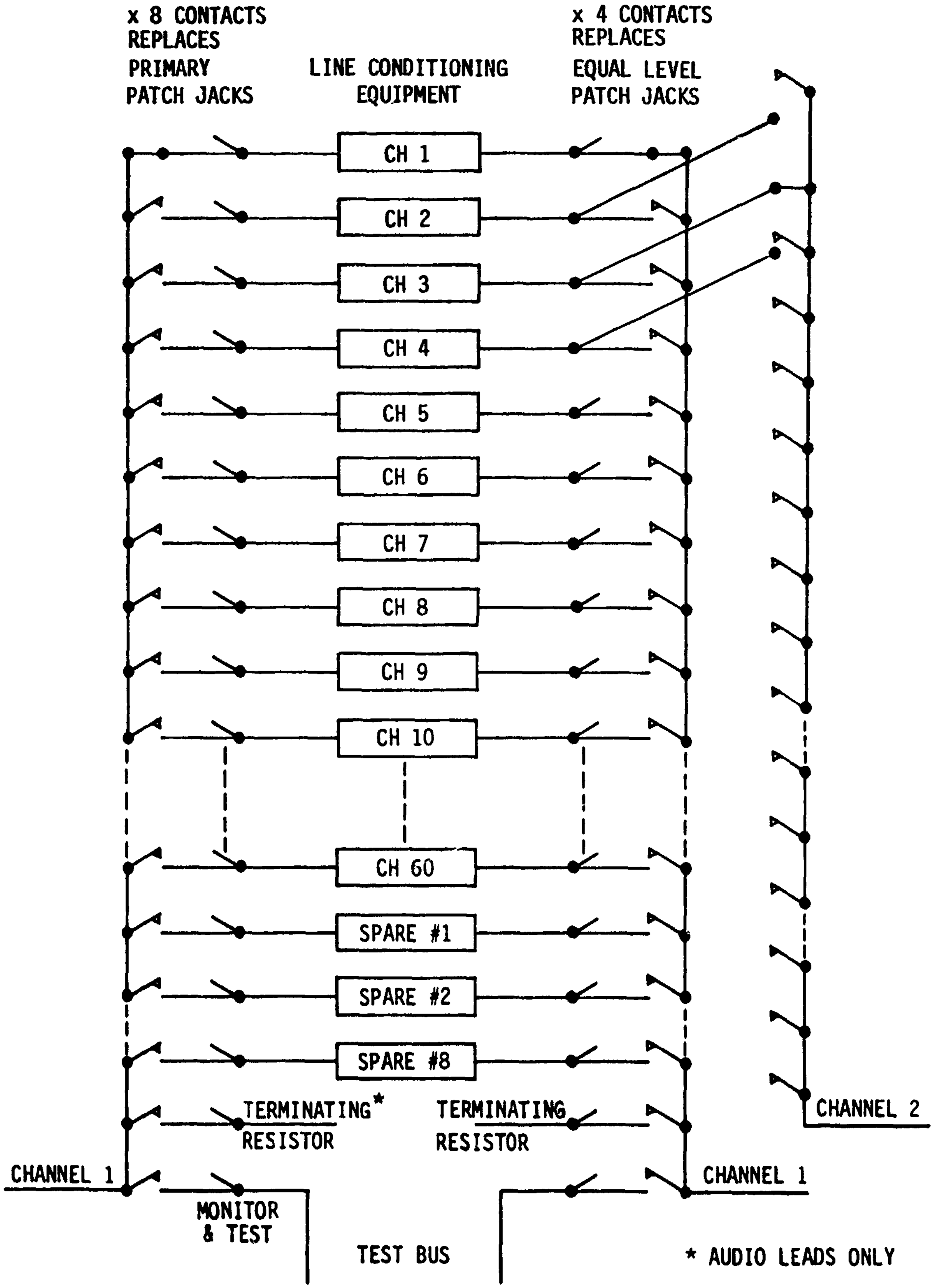
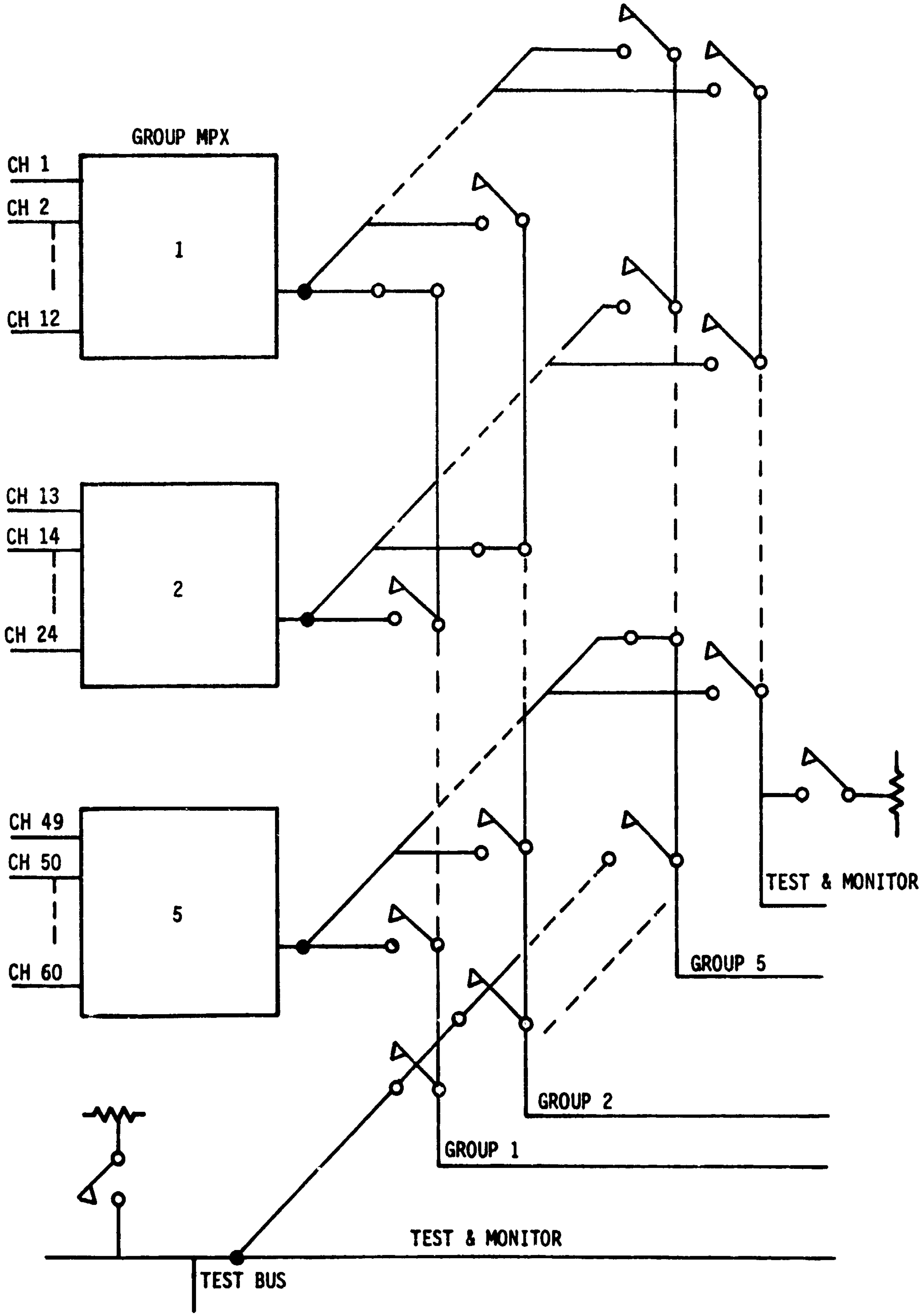


FIGURE 3-2 SEGMENT OF A FULL AVAILABILITY 60 CHANNEL NON BLOCKING MATRIX



FIVE GROUP FULL AVAILABILITY NON BLOCKING MATRIX

FIGURE 3-3

ANALOG TECHNICAL CONTROL REQUIREMENTS

60 CHANNEL FULL AVAILABILITY SYSTEM

USING A.D. DATA SYSTEMS INC. MATRIX

CIRCUIT PATCH JACK REQUIREMENTS (Primary)

8 leads per circuit (2 reed relays x 4 contacts)

60 channel access

10 channel Spare and Test

70 channel access

+ 1 isolation contact

71 channel x 2 Relays = $\frac{\text{142 Relays}}{\text{10 per PCB}}$ = 14.2 PCB per Channel

14.2 PCB per channel x 60 channel = 52 PCB for Circuit Patch Jacks

VF PATCH JACK REQUIREMENTS (Equal Level)

4 leads per circuit (1 reed relay x 4 contacts)

60 channel access

10 channel spare and test

70 channel access

+ 1 isolation contact

71 channel x 1 relay = $\frac{\text{71 relays}}{\text{10 per PCB}}$ - 7.1 PCB per channel

7.1 PCB per channel x 60 channel = 428 PCB for VF Patch Jacks

Table 3-1 (Sheet 1) Estimate of 60 Channel Full Availability Matrix

GROUP PATCH JACK REQUIREMENTS

4 leads per group (4 reed relays x 1 contact)
5 group access
2 terminations
2 test bus.

9 Group Patches

$$9 \text{ Group Patches} \times 1 \text{ relay} = \frac{9 \text{ relays}}{10 \text{ per PCB}} = 1 \text{ PCB per Group}$$

5 PCB for 5 Groups

852	PCB 4 wire reed relays @ 10/PCB @ $\simeq$	300.00	255,600
426	PCB 4 wire reed relays @ 10/PCB @ $\simeq$	300.00	127,800
5	PCB 4 wire reed relays @ 10/PCB @ $\simeq$	300.00	1,500
2	IEEE 488 Interface for 10,000 Cross PTS @	525	1,050
	Power Supply Option		420
2	56E Control Chassis @ 1400.00		2,800
43	56E Expansion Chassis @ 525.00		22,575
22	56E Expansion Chassis @ 525.00		11,550
1	μ Computer @ $\simeq$ 8,000		8,000
	Software		$\simeq$ 50,000
7	19" Relay Racks @ 100.00		700
	Minor Hardware # 10.00 per PCB		12,830
			$494,825

Table 3-1 (Sheet 2) Estimate of 60 Channel Full Availability Matrix

3.1.1 Advantages of Electro Mechanical Switches

Electro-mechanical switches provide nearly distortion and loss free connectivity over a wide bandwidth, and those of the reed relay variety are easily controlled by solid state circuitry.

3.1.2 Disadvantages of Electro Mechanical Switches

The following list covers some of the disadvantages associated with electro-mechanical matrices:

- Size: Electro-mechanical matrices are large and bulky in comparison to solid state circuitry.

- Expansion Limitations: The number of crosspoints required to double the number of terminations on a non-blocking matrix increases by a factor of four. The rule is the number of crosspoints increases by the square of the number of terminations.

- Cost: The material cost for electro-mechanical switching are increasing, and have now exceeded the cost of solid state circuitry. This is true with the blocking systems, and the differences are amplified when making a matrix non-blocking with full availability.

- Reliability: The moving parts used in relay crosspoint systems make them more susceptible to failure than solid state circuits.

- Maintainability: The ability to test crosspoint matrices is severely limited, and requires either special out-of-service routining circuits, special continuity testing circuits, or out-of-service continuity tests.

3.1.3 Electro-Mechanical Switching on a Limited Availability Basis

A considerable reduction in the cost of providing an alternative to manual patching with an electro-mechanical switching matrix can be realized by providing a non-blocking, limited availability matrix as depicted in Figure 3-4. This concept allows a normal through path through line conditioning equipment for each circuit, and spare equipments are multiplied across the matrix for use by a number of channels.

A cost estimate of a sixty channel system employing this approach is included as table 3-2. A full availability five channel matrix is included for group switching in this approach.

3.2 DIGITAL SWITCH CONFIGURATIONS

The modularly expandable digital switch identified is manufactured by Redcom Laboratories. This switch is 19" rack mountable, and can be expanded by "daisy chaining" additional modules to a configuration of a 240 port, non-blocking full availability system. The controls for this system are via either DTMF signaling or a standard RS-232-C computer interface. Figure 3-5 shows a concept drawing of how a sixty channel full availability, non-blocking network can be provided from these modules. Access is available for test, monitor, terminating and reconfiguration to any configuration of the sixty channels. A similar arrangement for five group switching is shown in Figure 3-6. The interface circuit for this switch, which will work directly with T-1 signals, will be available within approximately six months. Four wire E & M trunks can be made available within four months of order.

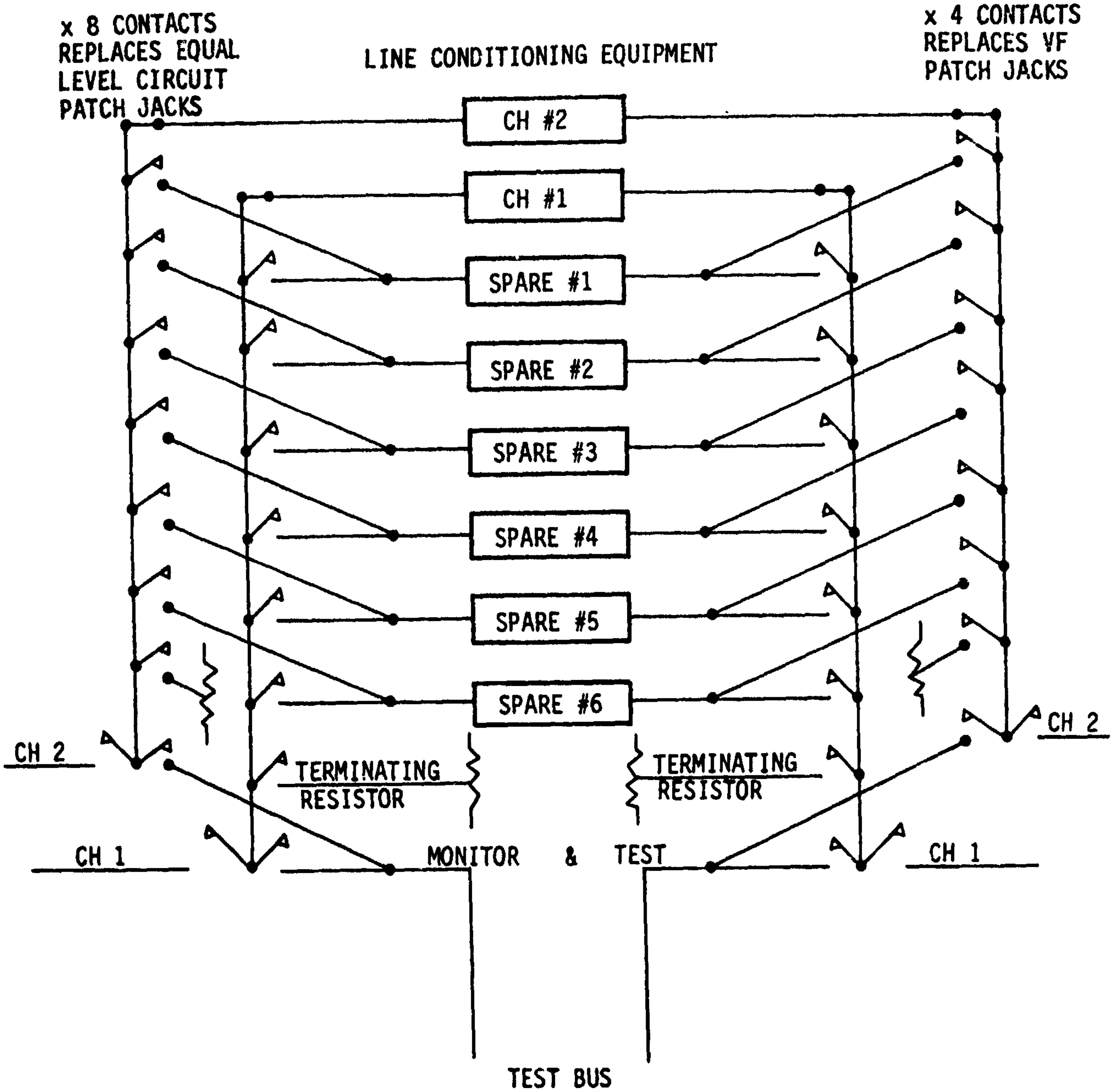


FIGURE 3-4 SEGMENT OF A LIMITED AVAILABILITY 60 CHANNEL CROSSPOINT MATRIX

ANALOG TECHNICAL CONTROL REQUIREMENTS

60 CHANNEL LIMITED AVAILABILITY

SYSTEM

(Using A.D. DATA Systems Inc. Matrix)

CIRCUIT PATCH JACK REQUIREMENTS (Primary)

8 Leads Per Circuit (2 Reed Relays x 4 Contacts)

60 Channels

1 Channel EA

6 Spare Channel EA (Multipled)

2 Test Access

1 Termination

$$\frac{10 \text{ Channel} \times 8 \text{ Contacts} \times 60 \text{ Channels}}{40 \text{ Contacts/PCB}} = 120 \text{ PCB}$$

VF PATCH JACK REQUIREMENTS

4 Leads Per Circuit

60 Channels

1 Channel

6 Spare

2 Test Access

1 Termination

$$\frac{10 \text{ Channel} \times 4 \text{ Contacts} \times 60 \text{ Channels}}{40 \text{ Contacts/PCB}} = 60 \text{ PCB}$$

Table 3-2. Cost Estimate of a 60 Channel Limited Availability Matrix (Sheet 1)

GROUP PATCH JACK REQUIREMENTS

4 leads per Group (1 Reed relay x 4 contacts)

5 Group access

2 Terminations

2 Test Bus

9 Group Patches

9 Patches x 1 relay = $\frac{\text{9 Relays}}{\text{10 Relays Per PCB}}$ = 1 PCB per Group

5 PCB for 5 Groups

120 PCB 4 Wire Reed Relays @ $\approx$ 300	36,000
60 PCB 4 Wire Reed Relays @ $\approx$ 300	18,000
5 PCB 4 Wire Reed Relays @ $\approx$ 300	1,500
1 IEEE 488 Interface for 10,000 crosspts. @ 525	525
Power Supply Option	420
1 56E Control Chassis @ 1400	1,400
9 56E Expansion Chassis @ 525	4,425
1 μ computer @ $\approx$ 8,000	8,000
Software @ $\approx$ 50,000	50,000
2 19" Relay Racks @ 100	200
Minor Hardware @ 10/PCB	1,850
	$122,320

Table 3-2. (Sheet 2) Cost Estimate of a 60 Channel Limited Availability Matrix

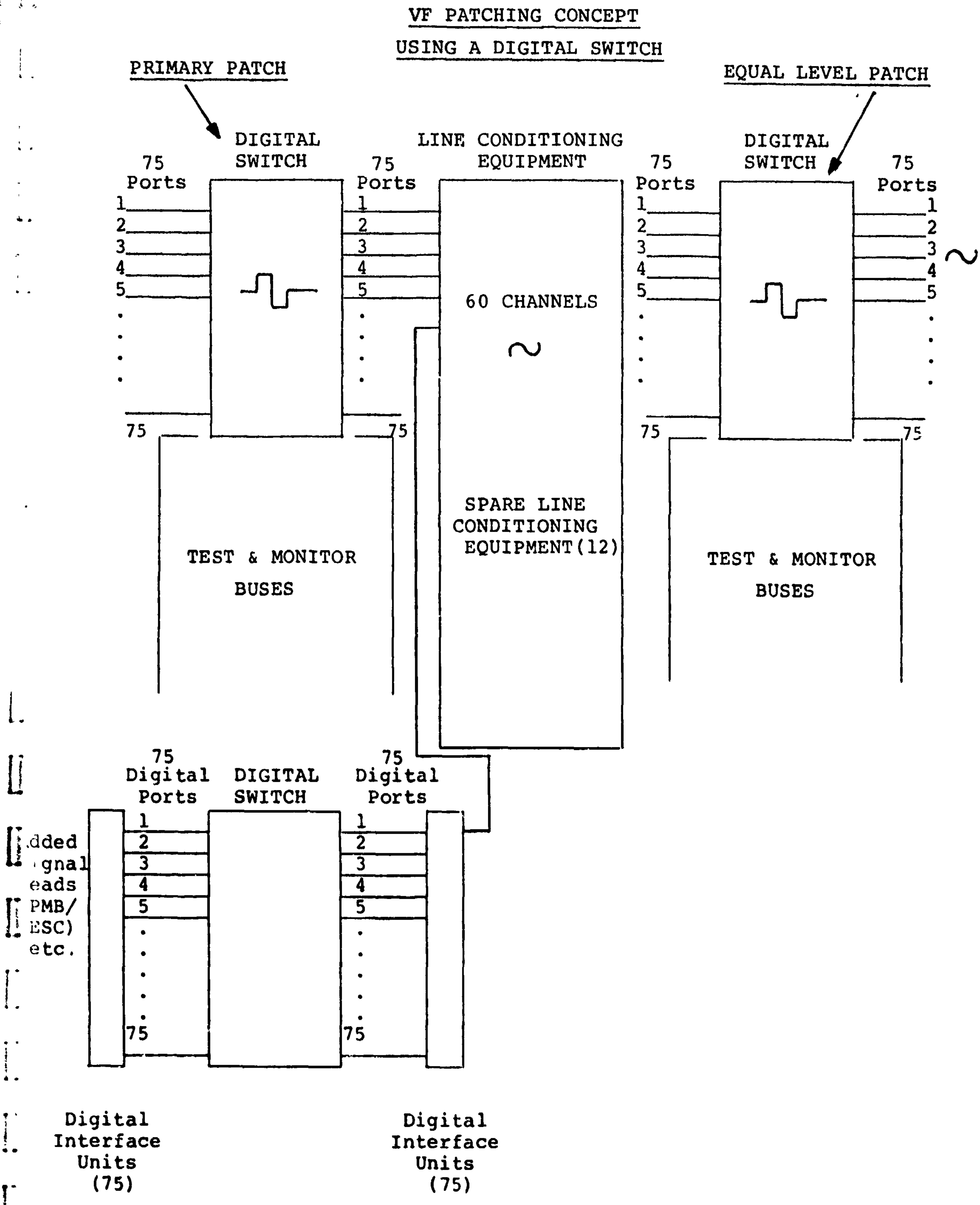


Figure 3-5. Concept of 60 Channel Full Availability, Non-Blocking VF Switching Modules

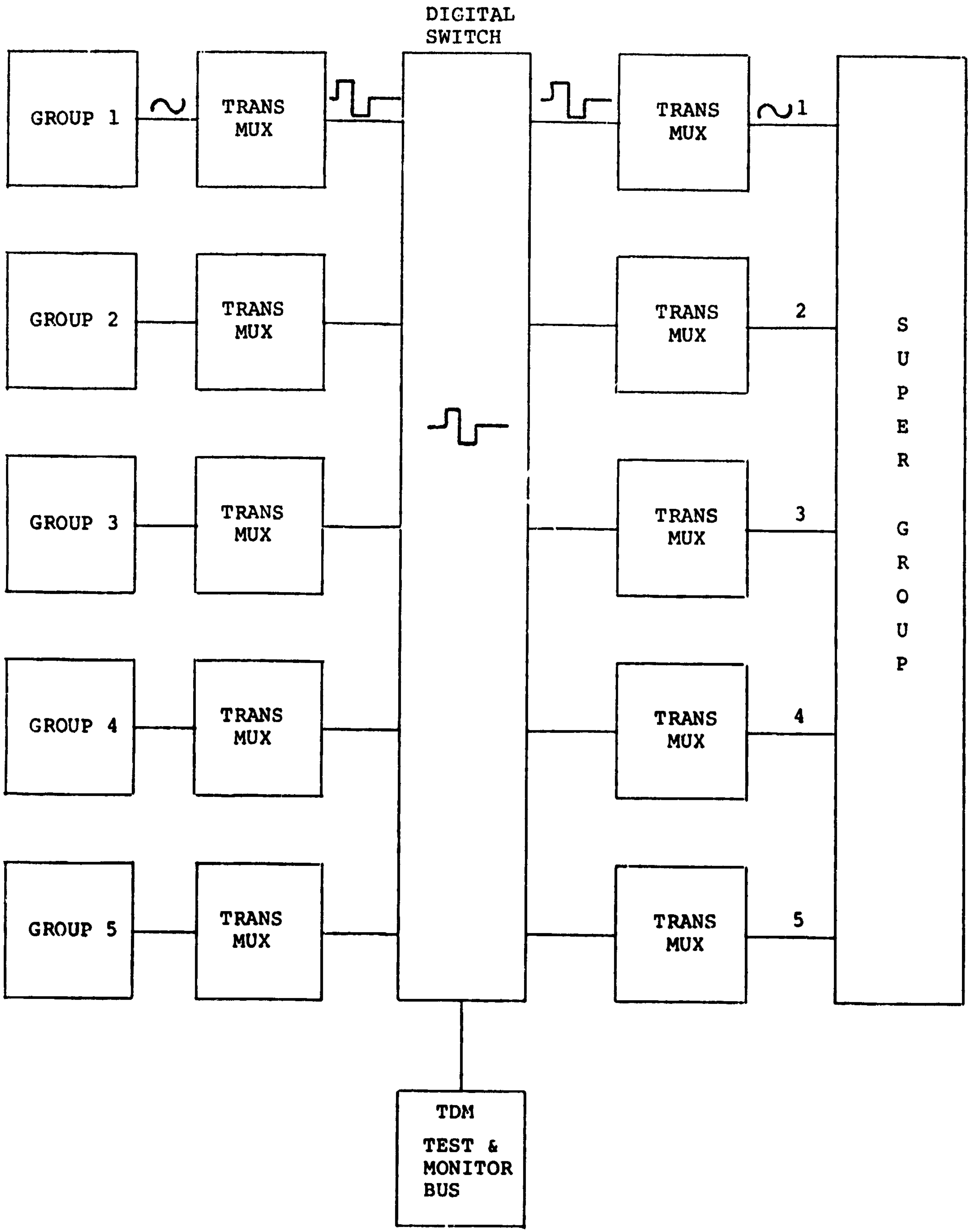


Figure 3-6. Concept of Five Group Non-Blocking, Full Availability Switching

3.2.1 Advantages of Digital Switches

The following list covers the major advantages of digital switching networks:

- Size: Digital Switching Networks require as little as 1/6 of the space of analog matrices.

- Ease of Expansion: Expansion of modules can be effected by daisy chaining modules up to the maximum size.

- Cost: Solid state circuitry causes the price of digital switches to be lower than cross-point hardware.

- Reliability: Solid state circuits are more reliable than mechanical assemblies.

- Maintainability: Solid state test points are easily sampled, and most digital switch diagnostics are capable of isolating faults to the PCB level.

3.2.2 Disadvantages of Digital Switches

The following list covers the most severe disadvantages of digital switches:

- Envelope Delay Distortion: The encoding of analog VF signals introduces slight high frequency delay distortion which is negligible on a one-switch connection; however, when a large number (9) of A/D and D/A conversions are required, it becomes great enough to fail S-3 conditioning parameters.

- Requirement for Outboard Components: Switching of group level FDM signals requires a trans multiplexer, and passing D.C. signals requires the use of digital interface units.

3.2.3 Cost of Digital Switching Equipment

Table 3-3 is a cost estimate of a 60 channel, VF, non-blocking, full availability system and a 5 group, non-blocking, full availability system. This cost can be directly compared with the cost estimate of Table 3-1. for a similar analog, cross-point matrix system. The digital interface units (DIU) and 150 of the switch ports in Figure 3-5 , could be eliminated by a special parallel to serial converter which would encode samples of the added signal leads into the PCM bit stream. Although such a unit is not presently available, development does not appear to be a particularly difficult proposition.

3.2.4 Overcoming Envelope Delay Distortion

The envelope delay distortion introduced by analog to digital conversions could be eliminated by treating it in each station with delay equalizers. These units are presently in use on all S-3 analog circuits, and could provide the additional compensation necessary on a circuit-by-circuit basis. Circuits not presently equipped could be ignored because they are not now designed for S-3 parameters.

3.3 IMPLEMENTATION

From the standpoint of inital cost, the limited availability electro-mechanical approach is the most cost effective of the three approaches presented for an analog technical control. A deeper look is necessary, however, to explore the most practical method of implementation in the light of transmission and switching system evolution to digital technology.

3.3.1 Pure Digital Environment

In the future pure digital environment, interface from switch to transmission system will most efficiently be on a digital group (24 channel) basis. This eliminates the requirement for individual circuit line conditioning equipment, and the conversions from analog to digital and digitial to analog for each connection. Individual circuit test access can be provided by a patchable D-bank, or by specially designed test equipment now being developed by test and digital equipment manufacturers.

Constant monitoring of the digital bit stream and alarms is provided, and reconfiguration can be provided by automatic built in fallback switching.

3.3.2 Pure Analog Environment

So long as analog transmission and switching systems are in use and no changes or upgrades to digital are planned, the limited availability electro-mechanical system is the most cost effective approach.

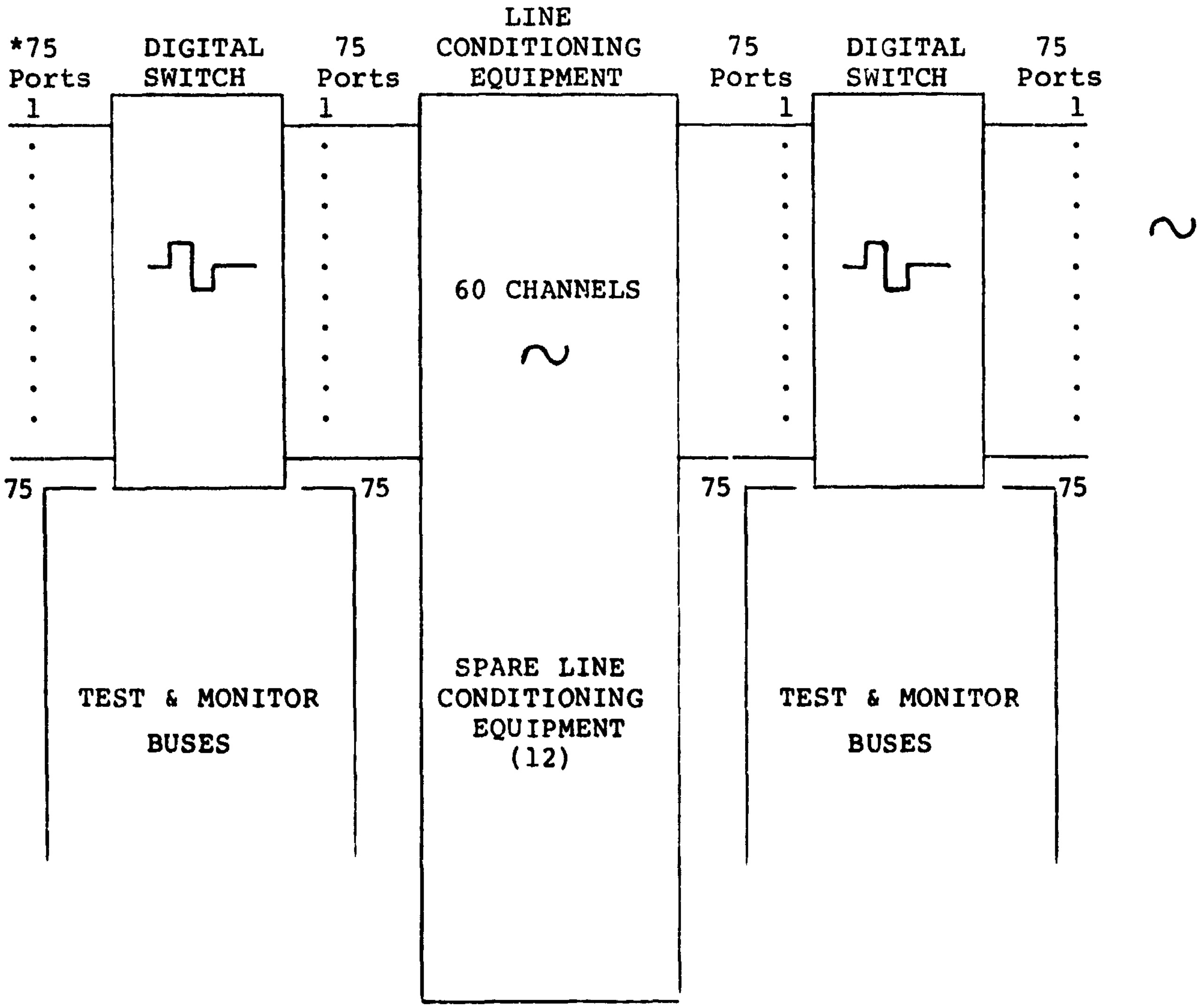
3.3.3 Hybrid Analog-Digital Environment

The direction the DCS and other systems are taking includes the replacement of analog transmission systems with digital transmission systems, with the replacement of analog switching systems following on an as economical basis. Given this set of circumstances, a more in-depth look at the digital switched control and its place in the evolutionary process is necessary. Figure 3-7. shows the VF patch replacement by a digital switch with a modification to make it compatible with 4 lead signaling and 4 lead transmission (e.g. XMT, RCV, E/M, PMB., and ESC.). This method considerably reduces the cost of the digital switch approach. An additional reduction in this cost can be realized by providing electro-mechanical switching at the Group level. Table 3-4. is a cost estimate of a 60 channel system of this type.

ANALOG TECHNICAL CONTROL REQUIREMENTS
60 CHANNEL FULL AVAILABILITY SYSTEM
USING REDCOM LABORATORIES DIGITAL SYSTEM

CIRCUIT PATCH JACK REQUIREMENTS (Primary)			
10	Digital Switch Modules	@ $13,000	$ 130,000
150	Digital Interface Units	@ 1,500	225,000
8	Interconnecting Cables	@ 50	400
VF PATCH JACK REQUIREMENTS (Equal Level)			
5	Digital Switch Modules	@ $13,000	$ 65,000
4	Interconnecting Cables	@ 50	200
GROUP PATCH JACK REQUIREMENTS			
8	Digital Switch Modules	@ $13,000	$ 104,000
7	Interconnecting Cables	@ 50	350
10	Transmultiplexers	@ 9,550	95,500
8	19" Racks	@ 100	800
μ	Computer		$ 8,000
	Software		50,000
			$ 679,250

Table 3-3. Analog Technical Control Requirements 60 Channel Full Availability System Using Digital System



* Switch modified
to handle PMB
and ESC signaling

FULL ANALOG TECHNICAL CONTROL

Figure 3-7. Concept of a 60 Channel Full Availability Switching Module, Modified to Handle 8 Leads, 4 VF & 4 DC

ANALOG TECHNICAL CONTROL REQUIREMENTS

60 CHANNEL FULL AVAILABILITY SYSTEM

USING MODIFIED MODULAR DIGITAL SWITCHES (REDCOM LABS)

FOR VF LEVELS AND (A.D. DATA SYSTEMS INC.)

ELECTRO-MECHANICAL MATRICES FOR GROUP LEVELS

CIRCUIT PATCH JACK REQUIREMENTS (Primary)

5	Modified Digital Switch Modules	@≃ 15,000	$ 75,000
4	Interconnecting Cables	@ 50	200

VF PATCH JACK REQUIREMENTS (Equal Level)

5	Digital Switch Modules	@ 13,000	65,000
4	Interconnecting Cables	@ 50	200

GROUP PATCH JACK REQUIREMENTS

4	Leads per Group		
5	Group Access		
2	Test Access		
2	Terminations		
9	Group Patches		
x 1	(4 wire relay)		
9	Relays/10 per PCB = 1 PCB per Group x 5 PCB for 5 Groups		
5	PCB 4 wire Reed relays	@ 10/PCB @≃ $300	1,500
1	IEEE 488 Interface for 100 or less crosspoints	@ 420	420
1	56E Chassis	@ 1,400	1,400

Table 3-4. (Sheet 1 of 2) Cost Estimate of a 60 Channel Full Availability, Non-Blocking Combined Digital/Analog Technical Control Switching Module

ANALOG TECHNICAL CONTROL REQUIREMENTS
(continued)

GROUP PATCH JACK REQUIREMENTS (continued)

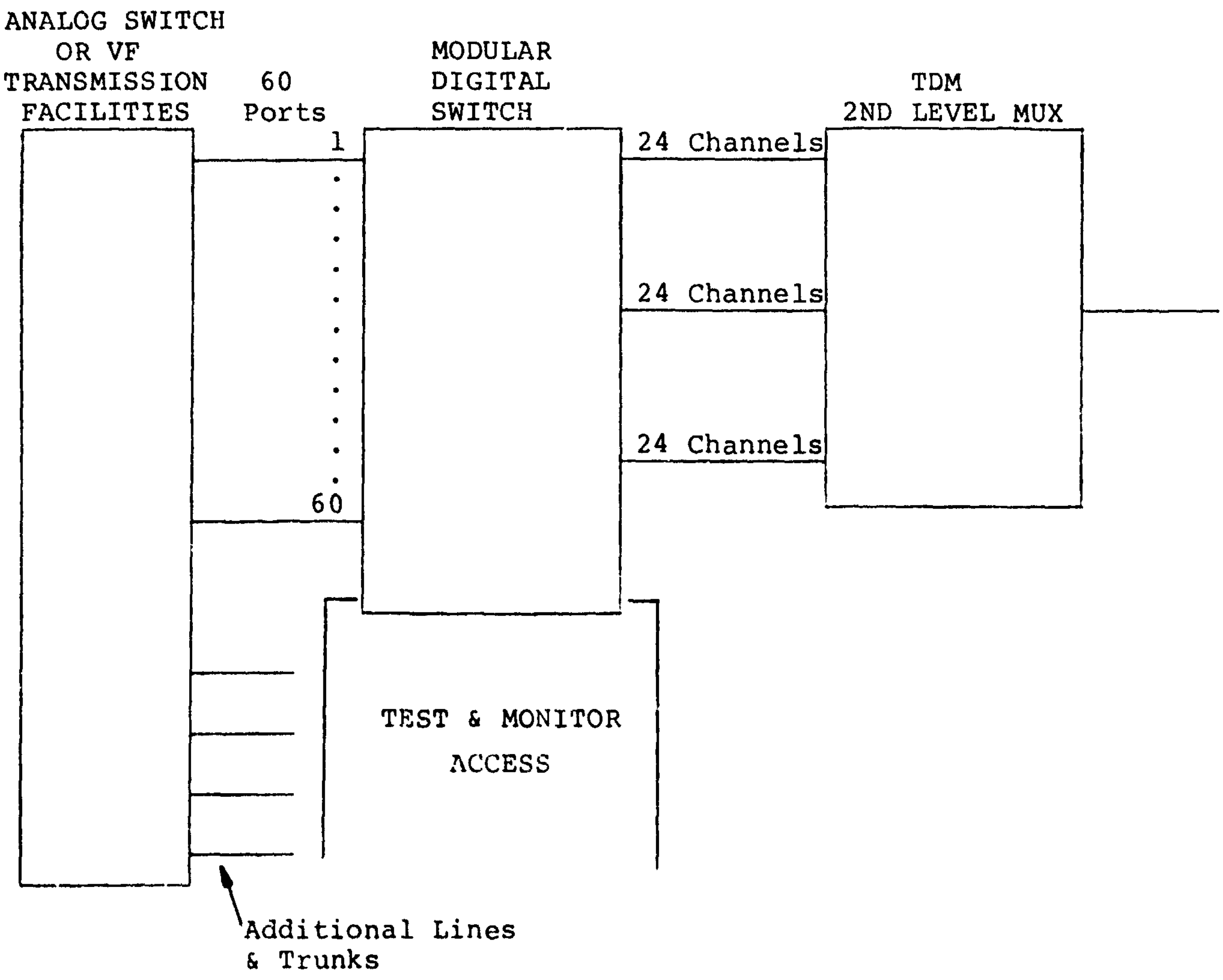
3	19" Relay Racks	@ 100	$ 1,300
	Minor Hardware	@ $10 per PCB	50
	μ Computer	@ ≃ 8,500*	8,500
	Software	≃	55,000*
			$207,570

* These costs will increase because of using a combination of IEEE 488 Bus and RS232C Buses

Table 3-4. (Sheet 2 of 2) Cost Estimate of a 60 Channel Full Availability, Non-Blocking Combined Digital/Analog Technical Control Switching Module

As the evolution to a digital transmission system on one side, and analog VF or switch facilities on the other side of this type technical control takes place, the configuration would become as shown in Figure 3-8 . This configuration eliminates all line conditioning equipment, FDM group multiplexers and most of the problems associated with the technical control. Figure 3-8 depicts this configuration, and Table 3-5 shows the total cost of providing the necessary switching for this configuration.

As the system becomes totally digital, as depicted in Figure 3-9, the requirement for switching will no longer exist if restoral is provided on a group basis.



ANALOG SWITCH OR VF TRANSMISSION FACILITY INTERFACE

WITH DIGITAL TRANSMISSION SYSTEM

Figure 3-8. Concept of a 60 Channel Full Availability Switching Module Working Between an Analog Switch and a Digital Transmission System

HYBRID TECHNICAL CONTROL REQUIREMENTS

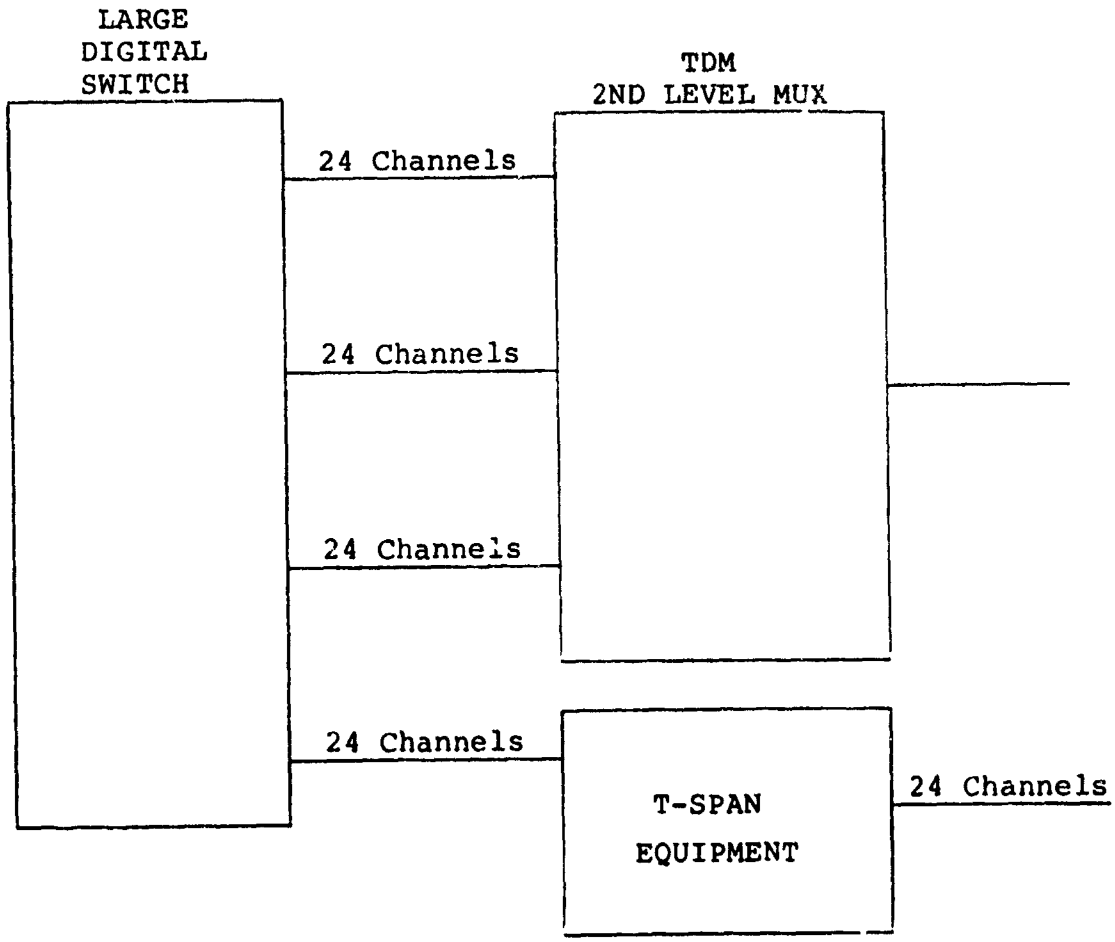
60 CHANNEL FULL AVAILABILITY SYSTEM

USING DIGITAL SWITCHES (REDCOM LABS)

CIRCUIT PATCH REQUIREMENTS

5	Digital Switch Modules	@	$13,000	$ 65,000
4	Interconnecting Cables	@	50	200
1	μ Computer	@	8,000	≃ 8,000
	Software			≃ 50,000
1	19" Relay Rack	@	100	100
				$ 123,200

Table 3-5. Cost Estimate of a 60 Channel Interface and Switching System Interfacing Between Analog Switch or VF Facilities and a Digital Transmissi n System



FULL DIGITAL TECHNICAL CONTROL

Figure 3-9. Full Digital Facilities

SECTION 4

ECONOMIC ANALYSIS OF 300 CIRCUIT VF TECHNICAL CONTROL

4.1 SUMMARY

This analysis assumes a three hundred circuit analog technical control currently manned by fifteen technical controller (AFSC 307XO) personnel.

Alternatives are presented for replacement of the patch and test facilities by computer controlled switching equipment capable of nailed-up connections, monitoring, test and reconfiguration, and cost associated with procurement and recurrent operations for each alternative.

4.1.1 Alternatives Considered

As a basis for comparison, the current cost of operating and maintaining the technical control patch and test facilities will be included as Alternative 1.

The following is a list of viable alternatives for performing the patching, testing and reconfiguration tasks, attendant to operation of an analog technical control of three hundred voice band circuits and five FDM Groups.

1. Current Costs of Operation and Maintenance
2. A System Employing Full Availability Electro-Mechanical, Computer Controlled 60 channel Patching, Testing and Reconfiguration Equipment modules.
3. A System Employing Limited Availability Electro-Mechanical, Computer Controlled 60 channel Patching, Testing and Reconfiguration Equipment Modules.
4. A System Employing Full Availability Digital-Solid State Computer Controlled 60 channel Patching, Testing and Reconfiguration Equipment Modules.

5. A System Employing a Full Availability Hybrid of Modified Digital and Electro-Mechanical Computer Controlled 60 channel Patching,Testing and Reconfiguration Equipment Modules.

4.1.2 Technical Alternative Comparison

The current alternative, Manual Patching and Testing, is extremely manpower intensive, and offers no hope of alleviation of that condition without a complete replacement of both long-haul transmission systems, and VF Facilities to facilities having inherent fallback switching.

Alternative 2, a full availability system made of computer controlled electro-mechanical matrices will permit manpower reductions of approximately eight personnel per 300 channel station. The use of the computer for control also opens the possibility of using automated test equipment presently being introduced into the inventory combined with multiplexers and data parts to operate the station with no technical controllers in attendance,' and bringing all test and reconfiguration control to a central control point.

Alternative 3 offers the advantages of Alternative 2 with two exceptions. Interchanging conditioning equipment strings is not possible, except among spares. Testing normally used line conditioning equipment strings on a terminated basis is not possible without removing the channel from service.

Alternative 4 offers the advantages of Alternative 2; however, requires a large number of outboard interface components.

Alternative 5, offers the advantages of Alternative 2 with the added advantage of being able to function in the hybrid world of digital long-haul transmission systems on one side, and analog switching or VF facilities on the other. This approach will facilitate a graceful evolution into the all digital world and allow an earlier-than-hoped-for elimination of much of the circuit/line conditioning equipment now required for individual 4 KHz channels in the DCS.

4.3.1 Alternative 1 - Recurring Cost of Current Operation and Maintenance

NR	TYPE PERSONNEL	ANNUAL COST	
1	MSGT 30770	28233	
1	TSGT 30770	24834	
4	SSGT 307X0	86912	
7	SGT 30750	136318	
2	A1C 307X0	35176	
TOTAL 307X0 PERSONNEL COST			$311,473

MAINTENANCE @ 2 HRS/DAY x 365 DAYS @ SSGT (Performed by Radio or Wire Maintenance Personnel)	$ 7,626
REPLACEMENT SUPPLIES AND EQUIPMENT (Parts under $1,000 for Patch Bays Only)	$ 444
ELECTRICAL COST	NEGLIGIBLE
TOTAL ANNUAL COST	$319,543

4.3.2 Long-Term Comparisons (Alternative 1)

FORMAT A - SUMMARY OF COSTS FOR ECONOMIC ANALYSIS/PROGRAM EVALUATION STUDIES

SUBMITTING DOD COMPONENT: U. S. AIR FORCE
DATE OF SUBMISSION AUGUST 1980
OBJECTIVE: COMPARE COST OF EXISTING AND COMPUTER CONTROLLED TECHNICAL CONTROL PATCH AND TEST FACILITIES
ALTERNATIVE: 1
STUDY PERIOD: 10 YEARS
DISCOUNT RATE: .100

YEAR	NONRECURRING R&D	NONRECURRING INVESTMENT	RECURRING COST	ANNUAL COST	DISCOUNT FACTOR	DISCOUNTED COST
1		0.	319,543	319,543	.9091	290,496.5
2		0.	319,543	319,543	.8264	264,070.3
3		0.	319,543	319,543	.7513	240,072.7
4		0.	319,543	319,543	.6830	218,247.9
5		0.	319,543	319,543	.6209	198,404.3
6		0.	319,543	319,543	.5645	180,382.0
7		0.	319,543	319,543	.5132	163,989.5
8		0.	319,543	319,543	.4665	149,066.8
9		0.	319,543	319,543	.4241	135,518.2
10		0.	319,543	319,543	.3855	123,183.8
TOTALS			3,195,430	3,195,430	6.1446	1,352,433

UNIFORM ANNUAL COST WITHOUT TERMINAL VALUE 301,473.3
TERMINAL VALUE (DISCOUNTED) 0. (0.)
TOTAL PROJECT COST (DISCOUNTED) (1,852,433)
UNIFORM ANNAUL COST WITH TERMINAL VALUE 301,473.3

4.3.3 Alternative 2 One Time Costs of A Three Hundred Channel System Made Up of Full Availability Electro-Mechanical Computer Controlled 60 Channel Patching, Testing and Reconfiguration Equipment Modules.

Equipment and Software Costs (First 60 Channels)	494,825
Additional 60 Channel Modules (4x 473,325) (Less Computer and Software + $500 per Interface Part)	1,749,300
TOTAL EQUIPMENT AND SOFTWARE COST	2,244,125
Gov't Engineering Support (Providing Detailed Module Interconnecting Specifications) (300 HRS @ GS-9)	3,647
Installation (3Month/3Man E-5)	15,042
On Site Engineering (3 Month @ GS-9)	5,835
Initial Spares Cost @ (.45 x .75 of Initial Equipment using single quantities of each type Module Total 18,925)	6,387
TOTAL ONE-TIME COST	$2,275,036

4.3.4 Alternative 2 Recurring Costs of A Three Hundred Channel System Made Up of Full Availability Electro-Mechanical Computer Controlled 60 Channel Patching, Testing and Reconfiguration Modules.

NR	TYPE PERSONNEL	ANNUAL COST
2	TSGT 30770	49668
3	SSGT 307X0	65184
2	SGT 30750	38948

TOTAL 307X0 PERSONNEL COST 153,800

MAINTENANCE @ 5 HRS PER WEEK X 52 WEEKS @ SSGT 2,716
(Performed by Radio or Telephone Switching Maintenance Personnel)

ELECTRICAL COST [(605 Appearances x 1 Watt x 8760 HRS) ÷ 1000] $.04/KWH 212

REPLACEMENT SUPPLIES AND EQUIPMENT ≃ 568
(Parts under $1000 for Equipment Replacing Patch Bays) .03 of Single Quantity of each type Module Total $18,925

TOTAL ANNUAL COST $157,296

4.3.5 Long-Term Comparisons (Alternative 2)

FORMAT A - SUMMARY OF COSTS FOR ECONOMIC ANALYSIS/PROGRAM EVALUATION STUDIES

SUBMITTING DOD COMPONENT: U. S. AIR FORCE
DATE OF SUBMISSION AUGUST 1980
OBJECTIVE: COMPARE COST OF EXISTING AND COMPUTER CONTROLLED TECHNICAL CONTROL PATCH AND TEST FACILITIES
ALTERNATIVE: 2
STUDY PERIOD: 10 YEARS
DISCOUNT RATE: .100

YEAR	NONRECURRING R&D	NONRECURRING INVESTMENT	RECURRING COST	ANNUAL COST	DISCOUNT FACTOR	DISCOUNTED COST
1		2,275,036	157,296	2,432,332	.9091	2,211,233
2		0.	157,296	157,296	.8264	129,989.4
3		0.	157,296	157,296	.7513	118,176.5
4		0.	157,296	157,296	.6830	107,433.2
5		0.	157,296	157,296	.6209	97,665.1
6		0.	157,296	157,296	.5645	88,793.6
7		0.	157,296	157,296	.5132	80,724.3
8		0.	157,296	157,296	.4665	73,378.6
9		0.	157,296	157,296	.4241	66,709.2
10		0.	157,296	157,296	.3855	60,637.6
TOTALS		2,275,036	1,572,960	3,847,996	6.1446	3,034,740.5

UNIFORM ANNUAL COST WITHOUT TERMINAL VALUE 493,887.4

TERMINAL VALUE (DISCOUNTED) 0. (0.)

TOTAL PROJECT COST (DISCOUNT) (3,034,740.5)

UNIFORM ANNUAL COST WITH TERMINAL VALUE 493,887.4

4.3.6 Alternative 3 One Time Costs of a Three Hundred Channel System Made up of Limited Availability Electro-Mechanical Computer Controlled 60 Channel Patching, Testing and Reconfiguration Equipment Modules.

Equipment and Software Costs (First 60 Channels)	122,320
Additional 60 Channel Modules (4x 64,320) (Less Computer and Software)	257,280
TOTAL EQUIPMENT AND SOFTWARE COST	$379,600
Gov't Engineering Support (Providing Detailed Module Interconnecting Specifications) (200 HRS @ GS-9)	2,431
Installation (1 Month/3Man E-5)	74,880
On-Site Engineering (1 Month @ GS-9)	2,107
Initial Spares Cost @ (.45 x .75 of Initial Equipment using single quantities of each type Module Total 18,925)	6,387
TOTAL ONE-TIME COST	$465,405

4.3.7 Alternative 3 Recurring Costs of A Three Hundred Channel System Made up of Limited Availability Electro-Mechanical Computer Controlled 60 Channel Patching, Testing and Reconfiguration Equipment Modules.

NR	TYPE PERSONNEL	ANNUAL COST	
2	TSGT 30770	49668	
3	SSGT 307X0	65184	
2	SGT 30750	38948	
	TOTAL 307X0 PERSONNEL COST		153,800
	MAINTENANCE @ 5 HRS PER WEEK X 52 WEEKS @ SSGT (Performed by Radio or Telephone Switching Maintenance Personnel)		2,716
	ELECTRICAL COST [(605 Appearances x 1 Watt x 8760 HRS) ÷ 1000] $.04/KWH		212
	REPLACEMENT SUPPLIES AND EQUIPMENT (Parts under $1000 for Equipment Replacing Patch Bays) .03 of Single Quantity of Each Type Module Total $18,925		≃ 568
	TOTAL ANNUAL COST		$157,296

4.3.8 Long-Term Comparisons (Alternative 3)

FORMAT A - SUMMARY OF COSTS FOR ECONOMIC ANALYSIS/PROGRAM EVALUATION STUDIES

SUBMITTING DOD COMPONENT: U. S. AIR FORCE
DATE OF SUBMISSION AUGUST 1980
OBJECTIVE: COMPARE COST OF EXISTING AND COMPUTER CONTROLLED TECHNICAL CONTROL PATCH AND TEST FACILITIES
ALTERNATIVE: 3
STUDY PERIOD: 10 YEARS
DISCOUNT RATE: .100

YEAR	NONRECURRING R&D	NONRECURRING INVESTMENT	RECURRING COST	ANNUAL COST	DISCOUNT FACTOR	DISCOUNTED COST
1		465,405	157,296	622,701	.9091	566,097.5
2		0.	157,296	157,296	.8264	129,989.4
3		0.	157,296	157,296	.7513	118,176.5
4		0.	157,296	157,296	.6830	107,433.2
5		0.	157,296	157,296	.6209	97,665.1
6		0.	157,296	157,296	.5645	88,793.6
7		0.	157,296	157,296	.5132	80,724.3
8		0.	157,296	157,296	.4665	73,378.6
9		0.	157,296	157,296	.4241	66,709.2
10		0.	157,296	157,296	.3855	60,637.6
TOTALS		465,405	1,572,960	2,038,365	6.1446	1,389,605

UNIFORM ANNUAL COST WITHOUT TERMINAL VALUE 226,150.6

TERMINAL VALUE (DISCOUNTED) 0. (0.)

TOTAL PROJECT COST (DISCOUNT) (1,389,605)

UNIFORM ANNUAL COST WITH TERMINAL VALUE 226,150.6

4.3.9 Alternative 4 One Time Cost of A Three Hundred Channel System Made up of Full Availability Digital-Solid State Computer Controlled 60 Channel Patching, Testing and Reconfiguration Equipment Modules.

Equipment and Software Costs (First 60 Channels)	679,250
Additional 60 Channel Modules (4x 621,750) (Less Computer and Software + $500 for Computer Interface Channel)	7,487,000
TOTAL EQUIPMENT AND SOFTWARE	$3,165,250
Installation (1 Month/3Man E-5)	74,880
On-Site Engineering (1 Month @ GS-9)	2,107
Initial Spares Cost @ (.50 x .75 of Initial Equipment using single quantities of each type Module Total 32,050)	12,019
TOTAL ONE-TIME COST	,255,256

4.3.10 Alternative 4 Recurring Cost of A Three Hundred Channel System Made up of Full Availability Digital-Solid State Computer Controlled 60 Channel Patching, Testing and Reconfiguration Equipment Modules.

NR	TYPE PERSONNEL	ANNUAL COST	
2	TSGT 30770	49668	
3	SSGT 307X0	65184	
2	SGT 30750	38948	
TOTAL 307X0 PERSONNEL COST			153,800
MAINTENANCE @ 1 HR PER WEEK X 52 WEEKS @ SSGT (Performed by Radio or Telephone Switching Maintenance Personnel)			522
ELECTRICAL COST [(605 Appearances x 1 Watt x 8760 HRS) ÷ 1000] $.04/KWH			212
REPLACEMENT SUPPLIES AND EQUIPMENT (Parts under $1000 for Equipment Replacing Patch Bays) (.03 of single quantity of each type Module Total $32,050)			≃ 962
TOTAL ANNUAL COST			$155,496

4.3.11 Long-Term Comparisons (Alternative 4)

FORMAT A - SUMMARY OF COSTS FOR ECONOMIC ANALYSIS/PROGRAM EVALUATION STUDIES

SUBMITTING DOD COMPONENT: U. S. AIR FORCE
DATE OF SUBMISSION AUGUST 1980
OBJECTIVE: COMPARE COST OF EXISTING AND COMPUTER CONTROLLED TECHNICAL CONTROL PATCH AND TEST FACILITIES
ALTERNATIVE: 4
STUDY PERIOD: 10 YEARS
DISCOUNT RATE: .100

YEAR	NONRECURRING R&D	NONRECURRING INVESTMENT	RECURRING COST	ANNUAL COST	DISCOUNT FACTOR	DISCOUNTED COST
1		3,255,256	155,496	3,410,752	.9091	3,100,714.6
2		0.	155,496	155,496	.8264	128,501.9
3		0.	155,496	155,496	.7513	116,824.1
4		0.	155,496	155,496	.6830	106,203.8
5		0.	155,496	155,496	.6209	96,547.5
6		0.	155,496	155,496	.5645	87,777.5
7		0.	155,496	155,496	.5132	79,800.5
8		0.	155,496	155,496	.4665	72,538.9
9		0.	155,496	155,496	.4241	65,945.9
10		0.	155,496	155,496	.3855	59,943.7
TOTALS		3,255,256	1,554,960	4,810,216	6.1446	3,914,798.4

UNIFORM ANNUAL COST WITHOUT TERMINAL VALUE 637,112

TERMINAL VALUE (DISCOUNTED) 0. (0.)

TOTAL PROJECT COST (DISCOUNT) (3,914,798.4)

UNIFORM ANNUAL COST WITH TERMINAL VALUE 637,112

4.3.12 Alternative 5 One Time Cost of A Three Hundred Channel System Made up of Full Availability Hybrid Modified Digital and Electro-Mechanical Computer Controlled 60 Channel Patching, Testing and Reconfiguration Equipment Modules.

Equipment and Software Costs (First 60 Channels)	207,570
Additional 60 Channel Modules (4 x 150,070) (Less Computer and Software + $1,000 for Computer Interface Channels)	600,280
TOTAL EQUIPMENT AND SOFTWARE	$807,850
Installation (1 Month/3 Man E-5)	74,880
On-Site Engineering (1 Month @ GS-9)	2,107
Initial Spares Cost @ (.50 x .75 of Initial Equipment Using single quantities of each type Module Total 36,800)	13,800
TOTAL ONE-TIME COST	$898,637

4.3.13 Alternative 5 Recurring Cost of A Three Hundred Channel System Made up of Full Availability Modified Digital and Electro-Mechanical Computer Controlled 60 Channel Patching, Testing and Reconfiguration Modules.

NR	TYPE PERSONNEL	ANNUAL COST	
2	TSGT 30770	49668	
3	SSGT 307X0	65184	
2	SGT 30750	38948	
TOTAL 307X0 PERSONNEL COST			153,800

MAINTENANCE @ 1 HR PER WEEK x 52 WEEKS @ SSGT (Performed by Radio or Telephone Switching Maintenance Personnel)	522
ELECTRICAL COST [(605 Appearances x 1 Watt x 8760 HRS) ÷ 1000] $.04/KWH	212
REPLACEMENT SUPPLIES AND EQUIPMENT (Parts under $1000 for Equipment Replacing Patch Bays) (.03 of single quantity of each type of Module Total 36,800)	≃ 1,104
TOTAL ANNUAL COST	$155,638

4.3.14 Long-Term Comparisons (Alternative 5)

FORMAT A - SUMMARY OF COSTS FOR ECONOMIC ANALYSIS/PROGRAM EVALUATION STUDIES

SUBMITTING DOD COMPONENT: U. S. AIR FORCE
DATE OF SUBMISSION AUGUST 1980
OBJECTIVE: COMPARE COST OF EXISTING AND COMPUTER CONTROLLED TECHNICAL CONTROL PATCH AND TEST FACILITIES
ALTERNATIVE: 5
STUDY PERIOD: 10 YEARS
DISCOUNT RATE: .100

YEAR	NONRECURRING R&D	: INVESTMENT	RECURRING COST	ANNUAL COST	DISCOUNT FACTOR	DISCOUNTED COST
1		898,637	155,638	1,054,275	.9091	958,441.4
2		0.	155,638	155,638	.8264	128,619.2
3		0.	155,638	155,638	.7513	116,930.8
4		0.	155,638	155,638	.6830	106,300.8
5		0.	155,638	155,638	.6209	96,635.6
6		0.	155,638	155,638	.5645	87,857.7
7		0.	155,638	155,638	.5132	79,873.4
8		0.	155,638	155,638	.4665	72,605.1
9		0.	155,638	155,638	.4241	66,006.1
10		0.	155,368	155,638	.3855	59,998.4
	TOTALS	898,637	1,556,380	2,455,017	6.1446	1,773,268.5

UNIFORM ANNUAL COST WITHOUT TERMINAL VALUE 288,589.7

TERMINAL VALUE (DISCOUNTED) 0. (0.)

TOTAL PROJECT COST (DISCOUNT) (1,773,268.5)

UNIFORM ANNUAL COST WITH TERMINAL VALUE 288,589.7

SECTION 5 - DIGITAL PATCH AND TEST SWITCHING

The conclusions reached in the subsequent paragraphs have been reached after researching equipment available from a cross-section of manufacturers and attempting to match available off-the-shelf equipment to the requirements of this tasks statement of work.

5.1 EIA-RS-232/CCITT V.24 EQUIPMENT

Modern equipment employing Modems and the EIA-RS232/CCITT V.24 Standard interfaces are easily accomodated by a wide variety of local or remote controlled off-the-shelf technical control patching, testing, and span switching equipment which can be employed for either local or remote control of all circuit segments.

5.2 K and D PATCH EQUIPMENT

The dearth of off-the-shelf switching Modules available to match the K, D, and M patch protocol leads to the conclusion that an approach similar to that employed for analog technical control would be the most workable. The economic analysis of Section four has shown the pure digital switch approach to be non-cost effective, primarily because of the outboard equipment required, and the non-blocking full availability electro-mechanical approach to be almost equally cost prohibitive.

The most practical approach appears to be that of providing a limited availability, electro-mechanical computer controlled matrix configured similar to the configuration shown in Figure 3-4

Table 5-1 shows a cost estimate of the circuitry required for a first thirty-two channel module of this type. Additional modules would be priced as shown in Table 5-2 Installation costs and other one-time costs can be calculated as shown in Section four.

DIGITAL TECHNICAL CONTROL REQUIREMENTS
32 CHANNEL LIMITED AVAILABILITY
SYSTEM (FIRST MODULE)
(USING A.D. DATA SYSTEMS INC. MATRIX)

K or D PRIMARY PATCH JACK REQUIREMENTS

6	Leads Per Circuit (3 Reed Relays x 2 Contacts)
32	Channels
1	Channel Per Ckt
4	Spare Channels
2	Test Access
1	Termination

$$\frac{\text{8 Channels} \times \text{6 Contacts} \times \text{32 Channels}}{\text{40 Contacts/PCB}} = \text{39 PCB}$$

K or D CIRCUIT PATCH JACK REQUIREMENTS

SAME REQUIREMENT AS PRIMARY = 39 PCB

Table 5-1. (Sheet 1) Cost Estimate of a First 32 Channel Digital Patching Module. (Made up of a Limited Availability Computer Controlled Crosspoint Matrix).

78	PCB 4 Wire Reed Relay @ $210	$16,380
1	IEEE 488 Interface for 10,000 or less Crosspoints @ $525	525
	Power Supply Option	420
1	56E Control Chassis @ $1400	1,400
4	56.E Expansion Chassis @ 525	2,100
1	μ Computer @ ≃ $8000	8,000
	Software @ ≃ $50,000	50,000
1	19" Relay Rack @ 100	100
	Minor Hardware @ $10/PCB =	780
	TOTAL	$79,705

Table 5-1. (Sheet 2) Cost Estimate of a First 32 Channel Digital Patching Module (Made up of a Limited Availability Computer Controlled Crosspoint Matrix).

DIGITAL TECHNICAL CONTROL REQUIREMENTS

32 CHANNEL LIMITED AVAILABILITY

SYSTEM (2ND & SUBSEQUENT MODULES)

78	PCI [illegible]ire Reed Relays @ $210	$16,380
1	IEE[illegible] [illegible]38 Interface for 10,000 or less Crosspoints @ 525	525
	Power Supply Option	420
1	56E Control Chassis @ 1400	1,400
4	56E Expansion Chassis @ 525	2,100
1	19" Relay Rack @ 100	100
	Minor Hardware @ $10/PCB =	780
		$21,705

Table 5-2. Cost Estimate of 2nd or Subsequent 32 Channel Digital Patching Modules (Made up of a Limited Availability Computer Controlled Crosspoint Matrix).

5.3 M PATCH MODULE

The overwhelming majority of circuits appearing at the M Patch rates of 1 to 3MB/second are T-carrier 24 or 32 channel groups at bit rates of 1.544MB/Sec. and 2.048MB/Sec. respectively.

5.3.1 T-Carrier Rates

Off-the-shelf switching equipment capable of switching T-carrier rates for test and reconfiguration are available at approximately $12,000 per group appearance. The flexibility offered by these switches is much greater than is necessary to reconfigure, monitor, and test group signals.

Most T-carrier equipment can be purchased with spare equipment built in and with fallback switching included to place any of a number of groups on spare equipment one-at-a-time upon detection of a pre-programmed Bit-Error-Rate Threshold, or frame slippage. This arrangement coupled with adequate monitoring of alarms appears to satisfy most operations.

5.3.2 Non-T-Carrier Rates between 1 and 3 MB/S

The military technical controls are faced with providing monitoring, testing and reconfiguration of a small number of circuits in the 1 to 3 MB/S range which utilize rates and protocal other than those of the 1.544 MB/S and 2.048MB/S signals. Most notable of these are some satellite digital groups.

5.3.3 Satisfying all M Patch Requirements

After determining that several data rates and not just the two standard T-rates, fall within the M Patch Module area, the requirements appear to be beyond the capability of off-the-shelf digital switching equipment. Digital switching equipment could be adapted to this requirement, and would probably function well; but only by being provided with special multiplexing equipment which would convert all possible 1-3MB/Sec. digital bit streams to one or two standard rates, and re-convert them to their original rate after being switched.

The requirement could apparently be satisfied for both T-carrier and non T-carrier bit streams by a computer controlled cross-point matrix, provided the crosspoints are able to pass the bandwidth required of them without imposing distortion. The configuration of such a system would be similar to that depicted in Figure 3.3 The cost would be as estimated in Table 5-3 Additional modules operating under the same computer's control would be as estimated in Table 5-4.

The modules required for this system can be added in building block steps; however, full availability of paths applies only to each eight group unit.

5.4 RECOMMENDATION

A limited availability, electro-mechanical computer controlled matrix is recommended for replacement of the K and D patch modules.

A full availability electro-mechanical computer controlled matrix appears to be the most practical for replacement of the M patch module; however, the parameters of the data stream for which the matrix is to be used must be carefully considered in matrix crosspoint selection.

COST ESTIMATE

M PATCH (FIRST MODULE)

4 Leads Per Group (1 Reed Relay x 4 Contacts)

8 Group Access

2 Terminations

2 Test Bus

12 Patches Per Group

12 Patches x 1 Relay = $\frac{\text{12 Relays}}{\text{10 Relays/PCB}}$ = 1.2 PCB Per Group

10 PCB For 8 Groups

10	PCB 4 Wire Reed Relays @ ≃ $300	$3,000
1	IEEE 488 Interface for 1000 crosspoints	420
1	56E Control Chassis @ $1400	1,400
1	Computer @ ≃ $8,000	8,000
	Software @ $50,000	50,000
1	19" Relay Rack @ $100	100
	(Will house 5 chassis)	
	Minor Hardware @ $10/PCB	100
	TOTAL	$63,020

Table 5-3 Estimate of First Module Non-Blocking Full Availability M Patch Module (Made up of a Computer Controlled Crosspoint Matrix).

M PATCH MODULE ESTIMATE

(SECOND OR LATER MODULES)

10	PCB	4 Wire Reed Relays @ ≃ $300	$3,000
1	56E	Expansion Chassis @ $525	525
		(1 with House 20 PCB)	
		Minor Hardware @ $10/PCB	100
			$3,625

Table 5-4. Estimate of Second or Later Non-Blocking Full Availability M Patch Module (Made up of a Computer Controlled Crosspoint Matrix).

APPENDIX A - LISTING OF INFORMATION SOURCES

(Materials, Companies, Equipment, Reports, etc.)

COMPANIES CONTACTED

ADC Magnetics Control Company
4900 West 78th Street
Bloomington, Minn., 55435

Dynatech Data Systems
7644 Dynatech Court
Springfield, VA 22153

Northern Telecom
International Plaza
Nashville, Tenn., 37127

Rolm Telecommunications
4900 Old Ironsides Drive
Santa Clara, CA 95050

Wiltron
825 East Middlefield Road
Mountain View, CA 94043

Wescom
P.O. Box 458
Downers Grove, IL 60515

Telecommunications Technology Inc.
555 Del Ray
Sunnyvale, CA 94086

Hekimian Laboratories
15825 Shady Grove Road
Rockville, Maryland 20850

Atlantic Research
5390 Cherokee Avenue
Alexandria, VA 22313

Redcon Laboratories
Freeport, New York

A-D Data Systems
200 Commercial Drive
Rochester, New York 14614

Electrospace Systems Inc.
1601 North Plano Road
Richardson, Texas 75081

APPENDIX A - LISTING OF INFORMATION SOURCES

(CONTINUED)

Granger Associates
5203 Leesburg Pike
Falls Church, VA 22041

Western Electric Company
225 Schilling Circle
Cockysville, MD 21030